DECEMBER 1957

Power Engineering

What We'll Need When Power Engineering Takes To Space 67
Know the Correct Practice for Using Oil and Grease Seals 70
Ball-Joint Fittings Make Compact Expansion Loops 73
When Fire Strikes a Power Station, What Next? 74
New Two-Stage Free-Piston Engine 77
Cooling Towers Noisy? – How You Quiet Them 78
Maintenance Records Prove Gas Turbines Rugged 82
Tools and Stores for That New Industrial Power Plant 83
Automatic Warning of Ice on Transmission Lines 86
Salt Water to Fresh – Several Ways 87
How D-C Braking Works on Induction Motors 90
G-E Reports on Causes of the Pittsburg Rotor Burst 91
New Look for Circuit Breakers and Switchgear 94
Use Your Operating and Maintenance Manuals Effectively 95

ATOMICS
Full Details of ETR – AEC's Newest Test Reactor 106
High-Temperature Nuclear Power Systems 111
Piping Systems and Metallurgy for Nuclear Plants 114

REGULAR DEPARTMENTS

Engineers' Preview 3
What They Tell Us 6
Helpful Bulletins 25
Construction News 46
Equipment News 48
News Reel 80
Power Engineering Handbook 96
Catalog Library 123
Reader Service Post Cards 123
Advertisers' Index 138
Annual Editorial Index 141
Circulation of This Issue 42,420

Hardened, Honed Seats

for tough throttling service

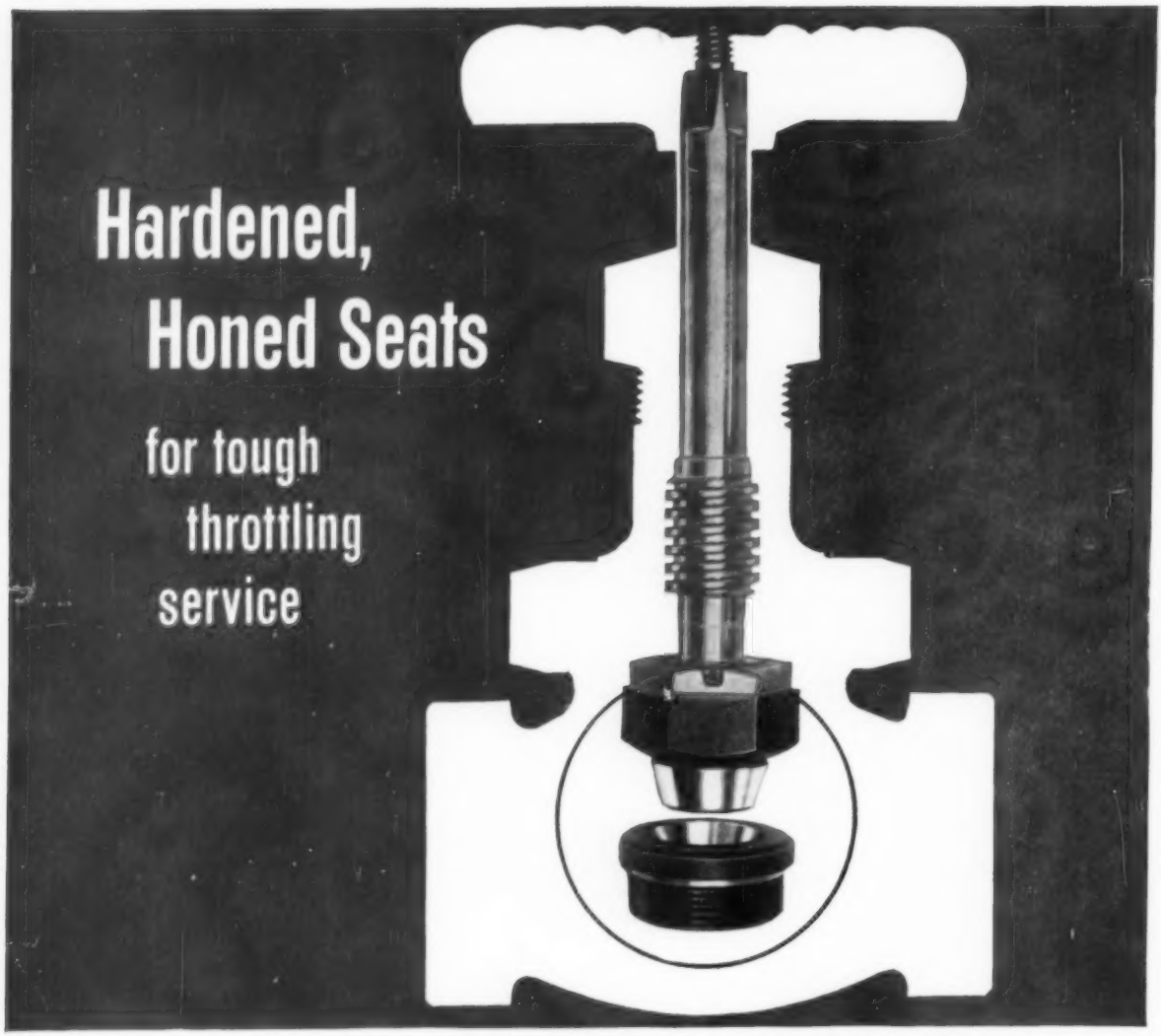

Fig. No. 558, bronze globe valve, 200 lbs. WSP, @ 550°F., 400 lbs. WOG, non-shock

A plug-disc and seat so hard they can crush scale between them and still close tight. A stem that absolutely will not gall or seize. The combination is in a rugged bronze valve designed for tough throttling service . . . the OIC 558!

Both plug-disc and seat are stainless steel, heat-treated to more than 500 Brinell hardness. Their seating surfaces are ground and *honed* to an accurate, smooth, bearing finish. The stem is OIC *alloy-40*, a sturdy bronze which won't gall or seize.

Remember, in throttling service a valve's stem, plug-disc and seat must withstand the most abusive wear. Rely on the toughness designed into this OIC line to give you extra-long service. Specify the modern 558 where you need bronze globe valves for throttling.

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P-507

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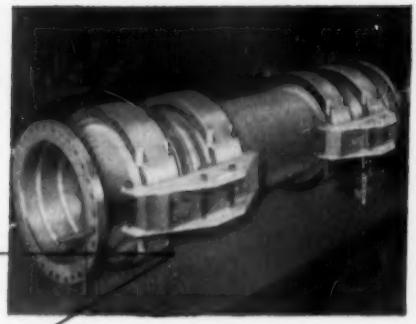
ALL IN A DAY'S WORK at *Pittsburgh Piping*



Every Pittsburgh Piping job is different, but all are alike in one respect . . . to control the flow and harness the energy of high temperature steam, gases, or liquids at high pressures. It's all in a day's work at Pittsburgh Piping to fabricate piping for a central station, an atomic energy installation, or for industrial and processing operations. Our service includes every phase from blueprint through erection: engineering, metallurgical control, pipe bending, machining, welding, heat treating, inspection, and testing. Use these facilities on your high temperature, high pressure piping jobs.

this BIG 10-TON EXPANSION JOINT

36" carbon steel joint, weighing ten tons, for cross-over piping in central station.

and this small PRESSURE RISER CONDENSER

Pressure riser condenser, fabricated of Stainless Steel Type 347; 2 feet high; wall thickness equivalent to 4" Schedule 160S. Stainless steel pressure vessel, for atomic energy application, appears in background.

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For more data circle 502 on Post Card

Hall Industrial Water Report

VOLUME 5 DECEMBER 1957 NUMBER 6

Keep Water Out of Steam

Water belongs in the boiler or evaporator, not in the steam. Wet steam from priming or foaming of boilers may seriously damage superheaters or turbines. Evaporator vapor of poor quality introduces excessive amounts of solids to the boiler feed cycle.

Carryover problems can be solved. Mechanical changes may be the most economical answer. Perhaps the water level should be lowered, or its variation controlled more carefully, or maybe the baffles in the steam drum should be altered. But the problem may be a chemical one. Is there unsuspected contamination of condensate or feedwater? Or is the answer simple adjustment of blowdown or use of an effective antifoam? Hall engineers are experienced in searching for the best way to avoid wet steam. They stand ready to help you.

More Blowdown

A Georgia plant, plagued with gross carryover from a small HRT boiler, had tried unsuccessfully to solve the problem with a number of compounds offered as effective cures. Usually the compounds aggravated the condition. Finally, Hall Laboratories was called in to help.

Hall field engineer John Kenney quickly diagnosed the problem. Little attention was given to blowdown of the boiler, so the total solids in the boiler water frequently ran much too high. After Kenney gave the operators the proper test procedures to control boiler water conditions and trained them to maintain total solids concentration at a satisfactory level, the difficulty was completely eliminated.

Simple, wasn't it? But only after a Hall engineer applied his training and experience to finding the actual cause of the carryover.

Dye Bath Trouble

In spite of heavy blowdown, careful control of boiler water conditions and normal boiler steam loads, a New England finishing plant experienced serious difficulty in dyeing operations because of impure steam. Conductivity tests on samples of condensed steam from the bleach house showed continuous carryover with dissolved solids ranging from 14 to over 300 ppm.

There was little if any room for improvement in boiler water conditions. There was no detectable contamination of boiler feedwater that could easily be eliminated. There was no simple mechanical solution to the problem. Hall field engineer Bob Dow decided accordingly to feed Hagan C-1 Antifoam. Carryover stopped immediately. Conductivity tests on samples collected under the same conditions as before showed only a trace of dissolved solids.

Further work indicated that with the use of the antifoam, blowdown could be cut in half with savings in water and chemicals. Needless to say, plant management is happy with Hall Laboratories service.

Hammers Stopped

The makeup water which constitutes about 70 percent of the feedwater at a forge plant in California contains 325 ppm hardness and 800 ppm dissolved solids. In addition, the condensate available and the exhaust steam used for feedwater heating are heavily contaminated with cylinder oil.

When Hall field engineer Dick Carey tackled the job he found boiler water level fluctuating badly and so much water in the steam that the continual stopping of the forging hammers was seriously interfering with production.

The only change that could be made at once was the feeding of Hagan H.P. Antifoam. This turned out to be all that was necessary. The water level stopped fluctuating, carryover ceased and so did any difficulty at the hammers.

Water is your industry's most important raw material. Use it wisely.

Foaming Traced to Size

During a regular visit to a New York paper mill, Hall field engineer Lou Eppelsheimer was informed that water was foaming in a condensate pump and that a heavy deposit had built up on a turbine throttle valve in a week's time.

Subsequent analysis showed the condensate to have a high pH value and to contain raw water, considerable silica and much organic matter. The deposit on the turbine throttle contained boiler water salts, indicating carryover. A most significant clue was that the foaming condition occurred only on Mondays.

With this information as a guide the plant men and the Hall engineer were able to pinpoint the difficulty. In the plant, the size emulsion was prepared with raw water, a silica compound and glue. The hot mixture was transferred from one tank and atomized into others with a steam injector. When steam pressure dropped over weekends the emulsion was sucked back into the steam lines. As operations were resumed on Monday, the contamination was flushed through the traps into the condensate return system.

Suitably placed check valves and regular examination of condensate have eliminated all difficulty.

Dr. Partridge Honored

When industrial water was selected as the 1957 topic for the Annual Marburg Lecture of the American Society for Testing Materials, Dr. Everett P. Partridge, Director of Hall Laboratories, was chosen as the lecturer. At the ASTM meeting in June, Dr. Partridge showed where we stand as a nation with respect to what he called "Your Most Important Raw Material." Reprints of his lecture will be available.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information write, wire or call Hall Laboratories, Division of Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa.

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

For more data circle 503 on Post Card

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NBP BPA

PUBLISHED SINCE 1896 FOR POWER ENGINEERS IN PRIVATE AND PUBLIC UTILITIES AND INDUSTRIAL PLANTS

ENGINEERS' PREVIEW

IRVING LANGMUIR'S LIFE and remarkable accomplishments in science have been given widespread attention and honor since his death at 76 on August 16, 1957. One of the most recent tributes is a 4-page brochure published by the General Electric Research Laboratory in Schenectady, where he did so much of his work. It contains memories of Langmuir by two old friends in research, Katharine B. Blodgett and W. D. Coolidge. Writes the latter:

"He was, by nature, very modest. By chance, I was the first person to whom he spoke just after receiving word by telephone of the award to him of a Nobel Prize. I can still see his look of both pleasure and modest incredulity."

TWO PIPING CONTRACTS totaling nearly $5,000,000 have been awarded to National Valve and Manufacturing Co by Commonwealth Edison Co of Chicago and the Tennessee Valley Authority.

The Commonwealth Edison contract calls for installation of 650 tons of special piping at the firm's Fisk Station to supply Chicago's growing power needs for homes and industry. The piping will carry 1050-F steam at 2000 psi from a twin furnace boiler to a 300,000-kw turbine. The steam is then returned through piping to the boiler where it is reheated for a second pass through the turbine. The system is designed to carry 2,200,000 lb of steam an hour.

Navco's contract with the TVA calls for power piping systems for two additional units of the TVA steam plant at Gallatin, Tenn. More than 500 tons of chromium molybdenum steel pipe will be used to transport a rated capacity of 1,960,000 lb of 1053-F steam an hour at extremely high pressures to turbines operating at 3600 rpm.

Sections of this special alloy pipe, some 27½ in. in diameter, will weigh 20 tons each. In some instances, a single pipe run weighing over 50 tons will expand more than a foot in length because of the high temperatures. A man can light a cigaret from the bare surface of this pipe when in operation.

Both the TVA and the Commonwealth Edison contracts call for the use of a counterpoise hanger to accommodate these heat-produced movements.

ELMER A. SPERRY AWARD, one of engineering's top prizes, this year went to three men and four sections of the Engineering Department of Electro Motive Division of General Motors Co, for contributions to development of the diesel-electric locomotive. The men are Harold L. Hamilton, Richard M. Dilworth, and Eugene W. Kettering. The award was made in Chicago in October as part of the Fall General Meeting of the AIEE.

Also at the AIEE meeting, William L. Everitt, dean of the College of Engineering, University of Illinois, was given the Institute's medal in electrical engineering education.

Some 1900 engineers turned out for the AIEE confab, heard many a pertinent paper, but none perhaps so pertinent as remarks by Dr. Kaj A. Strand, director of Northwestern University's Dearborn Observatory, at a press conference.

In questioning Dr. Strand, Associate Editor Charles Maxwell of POWER ENGINEERING observed that, according to our information, the satellite Sputnik I weighs 184-plus lb, while the original vehicle weighed some 60 tons at take-off. This indicates a ratio of about 650 to one (the best the USA has come up with is 1000 to one). Also, Russia's initial thrust was in the order of 200,000 lb as compared to the Vanguard's 27,000 lb. Maxwell asked Dr. Strand if these facts did not indicate that the Soviets had developed a better propellant, or a better rocket, or both. Strand checked figures he had and agreed that this was quite apparent.

For more on power for the satellite, see the article, Power Engineering Takes to Space, elsewhere in this issue.

ELECTRONIC BRAIN of a computer can remember only about one millionth as much as the human brain, when it comes to translating a foreign language such as Russian. This comforting fact was conveyed to the AIEE conference by Robert E. Wall, Jr., and Udo K. Niehause, of the University of Washington, in a symposium on computers. This is one of the reasons why machine translation at present should be done on a word-for-word basis, and not by translation of thought.

Another memorable description from AIEE, this one by Archer S. Gordon of the University of Illinois College of Medicine: a small, portable electrical device known as a cardiac monitor is being used to aid in detecting stoppage of the heart, fibrillation and collapse of that organ. The monitor, which uses transistors, gives a continuous, visual monitoring of the rate and rhythm of the heart, indicating its condition and serving as a guide in the case of an unconscious, pulseless person.

M. J. Steinberg, of ConEd, New York, reminded AIEE delegates that although fuel costs can be established as a function of the kw load generated, with acceptable precision, no method has as yet been developed to determine a similar relation for maintenance costs. Steinberg said that annual costs of accounting record can be utilized to establish incremental maintenance costs at a fixed unit value per kwh, or as a fixed percentage of the incremental fuel costs. He advocated a survey on current practices for determining incremental maintenance costs.

CLEVELAND STEPS OUT with construction plans for a major electric power plant located at Rayland, Ohio, on the Ohio River. Part of the Cleveland Electric Illuminating Co's system, the first unit of 335,000-kw capacity is scheduled to go on the line in 1961. It will be linked to the company's service area by a 345,000-v transmission line. Cost of the initial installation — plant, turbine-generator unit and connecting transmission system — is reported at $75,000,000. By building on the Ohio River near plentiful coal supplies, cost of transportation of coal will be reduced and the saving reflected in low-cost electric power.

ANOTHER BIG CONSTRUCTION project is the new dam, power house and water storage reservoir which will soon be added to the Southern California Edison Co's Big Creek hydroelectric installation in the High Sierra. Cost of the new facility is estimated at $49,600,000. It will add 126,000 kw of generating capacity to the total of 540,000 kw now being produced by the Big Creek chain of lakes, dams and powerhouses.

THE NEW LANGUAGE of atomics will get a much needed standard dictionary. ASME is publishing a 188-page Glossary of Terms in Nuclear Science and Technology. The work has been approved by the American Standards Association, an approval which is the culmination of a project begun in 1948 by 21 technical societies with interests in the nuclear energy field. These groups pooled their efforts toward one comprehensive listing of terms, with the National Research Council as coördinating body. The ASME's list was used as a base.

Copies of the new and definitive glossary may be obtained at $5 each from the ASME, 29 W 39th St, New York City, or from the American Standards Association, 70 E 45th St, New York City.

NEW TOPICS to be introduced at the ninth Plant Maintenance and Engineering Conference in January, reflect the rapidly changing aspects of maintenance in the nation's factories. Prevention of air and water pollution and the impact of automation on maintenance top the list of subjects to be discussed.

The conference is held annually during the first three days of the Plant Maintenance and Engineering Show, which is scheduled for the International Amphitheatre, Chicago, January 27 to 30.

Reduction of electric power bills, labor relations, and the broad responsibilities of plant engineering are among the new topics to be introduced this year. There will also be a new session devoted to the small-sized plant where less than ten employees are engaged in maintenance work.

Five general sessions will cover Getting Management Support for Maintenance, Fundamentals of Preventive Maintenance, Fundamentals of Planning and Scheduling, Fundamentals of Maintenance Cost Control, and Prevention of Air and Water Pollution. The pollution session will consider both outdoor pollution which causes serious community problems as well as in-the-plant pollution, which raises costs, interferes with employee health and comfort, and impedes quality control.

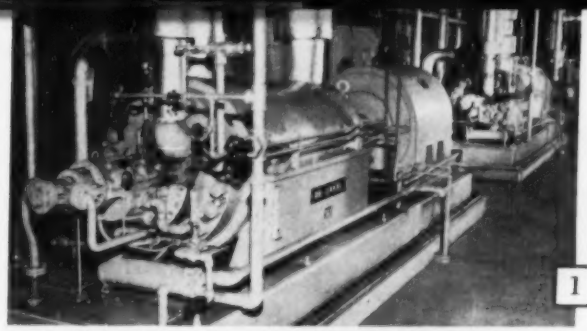
Ten industries will have separate sessions devoted to their respective problems. These include metal-working, petroleum processing, paper industries, research and development laboratories, rubber, chemical, metal-fabricating, food processing, foundries, and steel mills.

Welding, electric motors, sanitation, maintenance in plants with less than 50 maintenance employees, and getting work coöperation from maintenance employees, are among other topics for separate sessions.

SPEAKING OF NUCLEAR POWER (and who isn't these days) President Eisenhower has announced that 59,800 kg of uranium 235 will be available for peaceful uses at home and abroad. This is in addition to 40,200 kg designed in 1956 and earlier. Reason for the new supply: the point has been reached where licenses granted or under consideration by the AEC require it.

The growing nuclear power programs in friendly nations also require additional supplies of atomic fuel.

Of the new supply, 29,800 kg are for use outside the U. S.; 30,000 kg are for domestic use, principally for power reactors.



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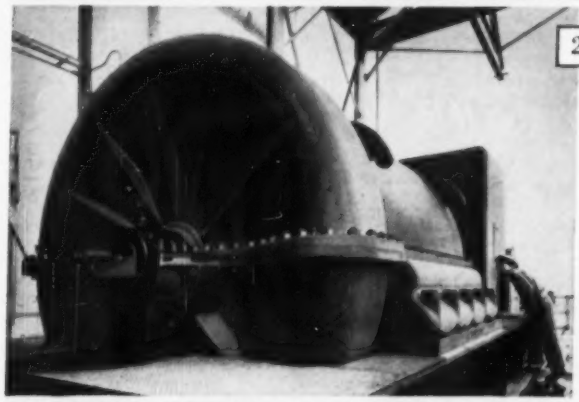

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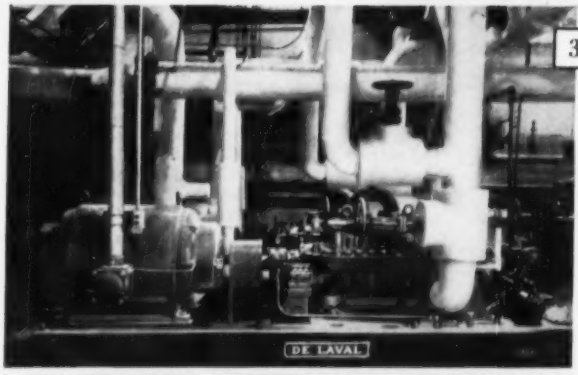

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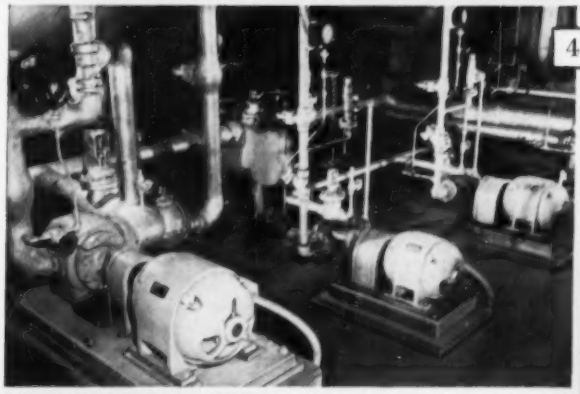

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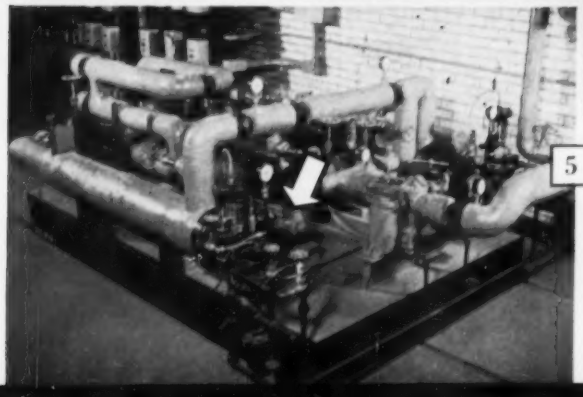

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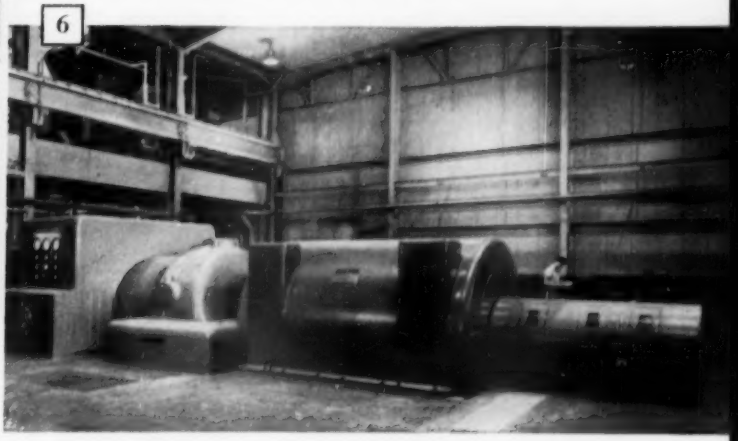
Machines that *stay* in service year in and year out are the most economical. Since 1901, De Laval has supplied quality-designed pumps, compressors, and other vital equipment for industry. Each unit is designed for dependability and built by master craftsmen. As a result, the De Laval name plate is your assurance of reliability. Literature is available on all equipment shown on these pages.

1. Barrel type boiler feed pumps
2. Centrifugal compressors
3. Centrifugal pumps for many services
4. De Laval IMO pumps for fuel oil transfer
5. De Laval IMO pumps for fuel oil burner service
6. Multi-stage turbine generators



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DE LAVAL

Steam Turbine Company

816 Nottingham Way, Trenton 2, New Jersey

DL-401

WHAT THEY TELL US

▶ **GAS TURBINE EXPERT** in the house? Reader C. T. Mabbi wants an answer to this one:

> The high efficiency of the combined gas-turbine steam-turbine cycle scheme is well known. The opportunities to exchange heat are various and valuable.
>
> However, in reviewing the information on the installation planned at Cordele, Ga., in POWER ENGINEERING, October, page 79, it occurs to me that the two could have been placed in tandem driving a 17,500-kw generator. (The original design is that a gas turbine drives a 5000-kw generator and a steam turbine drives a 12,500-kw generator.) Many economies would have resulted in manufacturing and in operation, as well as in space. Perhaps one economy would have been graduating into the hydrogen-cooled class, the breaking point being right around there. Also, the steam turbine could be used to start the gas turbine and compressor, eliminating the starting motor.
>
> I am convinced that the over-all length of compressor, two turbines and generator, would be well within dimensions already proved practicable.
>
> Can you give me an answer on this?

▶ **DRAINING SUPERHEATERS** before start-up is a practice which should be followed in any well-operated plant. Our attention has been called to this principle again by Reader D. I. Calleja of Key West, Fla. Calleja writes:

> Hearing of a power plant that had turbine thrust bearing damage, I thought that the damage might very well have been caused by water slug or moisture being carried into the turbine during the starting up of another boiler. The answer to the difficulty lies in pockets of accumulated condensate in the superheater tubes.
>
> I have had experience with such pockets, and although I didn't get thrust bearing damage, I did get a superheater tube leak. The trouble was that the boiler was being fired too slowly, causing poor circulation, and so not moving the condensate in the tubes. This resulted in high temperature in the tubes, causing tube leaks. We are now bringing up the steam much more quickly, checking to see that the tube temperature does not exceed 900 F. This has cured the trouble. Another way to eliminate it:
>
> Before firing up, be sure that the air vent and all superheater drains are opened. To insure thorough draining, open drain connection from all superheaters to the closed and/or open system on which they are installed. No steam flow will take place through a trap, and it will be necessary to establish positive steam flow through the superheater.
>
> Open the by-pass valve on the superheater 150-lb discharge auxiliary line, to allow the steam to flow slowly into the boiler. The boiler being cold, steam from the 150-lb line forces the air pocket out of the system via steam drums and air vents, also superheater vents. A small amount of condensate is left in the superheater element, which will serve as additional protection. Close the protection steam connection to the superheater inlet when steam drum pressure reaches 150 lb, and in any case by the time the steam drum pressure equals the pressure in the auxiliary line.
>
> The superheater drains to the open system should be used to check the presence of condensation in the superheater, and in any case should be opened for a sufficient length of time to insure that the superheater is free of condensate prior to lifting the safety valve by hand, and before cutting in on the main steam valve.
>
> Before cutting in on the main steam valve, I am careful to see that the non-return valve drain is open, which drains to the atmosphere. We also have a pipe connected to our main steam line with a trap; this trap has a by-pass, and an open drain, which I also open as well as opening the gland seal drain. All these valves, with the casing drain, are a "must" with me, for I will be pretty sure of getting dry steam.

▶ **HANDBOOK** section of POWER ENGINEERING continues to prove its practical usefulness to a wide range of readers. W. H. McKim, supervisor of installation and maintenance for Westinghouse's Atomic Power Division, asks:

> I am writing to determine if you have available in compiled form, editions of the Handbook which appears monthly in your publication.
>
> I am in the process of organizing a mechanical installation and maintenance section for a new nuclear power plant and I believe a handbook such as this would be most helpful in training and qualifying new personnel. If this is available please let me know the cost and any other pertinent ordering information.
>
> It may please you to know that my copy of POWER ENGINEERING is regularly circulated to all engineers and foremen here, and we all find it to be a most helpful and well-written publication.

We appreciate this comment, and wish we could comply with Reader McKim's request. Earlier issues of the Handbook section were grouped and reprinted in booklet form, but the supply of these is now exhausted.

▶ **CREW TRAINING** for power plant operation, and successful techniques for it, is a subject which always has our interest and concern. In the August, 1956 issue (pages 101–3) we published what we thought was a very helpful article by G. R. Setterlund, called How We Instructed a New Steam Plant Crew. Others have apparently thought so, too.

Reader E. B. Plapp, chief engineer of the Mexican Engineering Department of American Smelting & Refining Co, writes from El Paso, Texas, wanting to know how Setterlund would handle the training problem when some operators are Spanish-speaking. (Readers of the Setterlund article will remember that one of the factors he had to deal with was a mixed group of English-speaking and French-speaking operators.) Plapp asks further:

> What I wanted was a sample of operating instructions which we could use in writing up instructions for our own plant; in other words, we know what to include and write up, but we are not sure of just what form to put it in.

Setterlund has graciously replied to Plapp with detailed suggestions based on the system he described in our August, 1956 issue. He comments:

> Each plant has its own individual problems when training and instruction sheets are being compiled; but I find that the over-all picture is roughly the same. Anybody can become an operator if he is able to think for himself, is taught the "why's" and supervised while training.

▶ **GENTLEMAN FROM JAPAN,** T. Kishi of the Nippon Asbestos Co, in Tokyo, writes:

> I am a diligent reader of your publication. I read with much interest an article entitled, How To Fireproof Your Fuel Tanks, on page 91 of the August, 1957 issue, and would like to know about it in more detail. I would appreciate it if you would kindly arrange with the manufacturer and have a copy of the maker's bulletin sent to me via airmail at their earliest convenience.

By this time we expect and hope that Reader Tishi has probed to the full the interesting story on perlite concrete and what it can do. Anybody else need more information?

Why a Steam Trap Has to Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

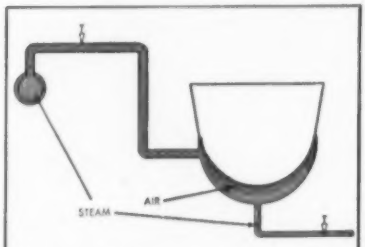


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

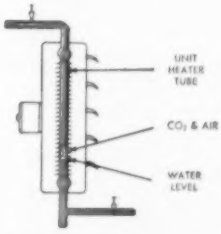


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates the situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

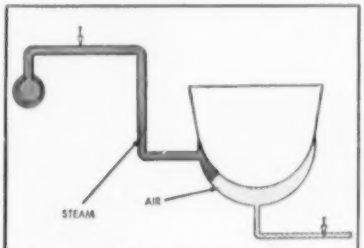


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

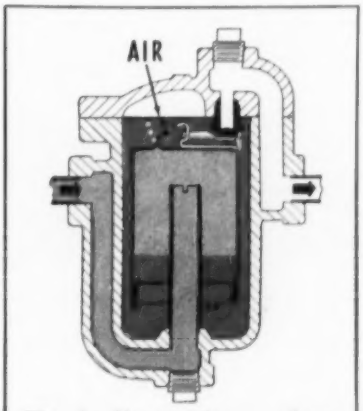
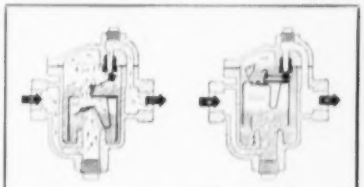


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

Open Float with Thermostatic Vent

Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

* * *

The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8103 Maple Street, Three Rivers, Michigan.

ARMSTRONG STEAM TRAPS

For more data circle 505 on Post Card

What are your needs for

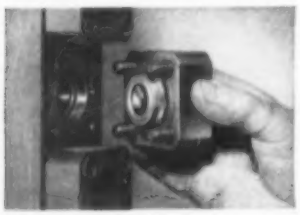
YARWAY COLOR-PORT WATER LEVEL GAGE

You get a *triple advantage* with the Yarway COLOR-PORT boiler water level gage for pressures to 3000 psi.

Two-color readings are brilliant and clear. Water shows green; steam shows red. A full gage is all green and an empty gage all red.

Low maintenance with individual cover-glass assemblies, each held solidly in place by four socket head cap screws. "Floating assembly" design applies safe, predetermined loads on glass ports, reducing thermal shocks, permitting faster warm-up.

Increased availability means longer service life. Cover glass assemblies can be *serviced in place*, easily and quickly.



Yarway Bulletin WG-1814 describes the Color-Port Gage. Write for it.

YARNALL-WARING COMPANY
100 Mermaid Avenue
Philadelphia 18, Pa.
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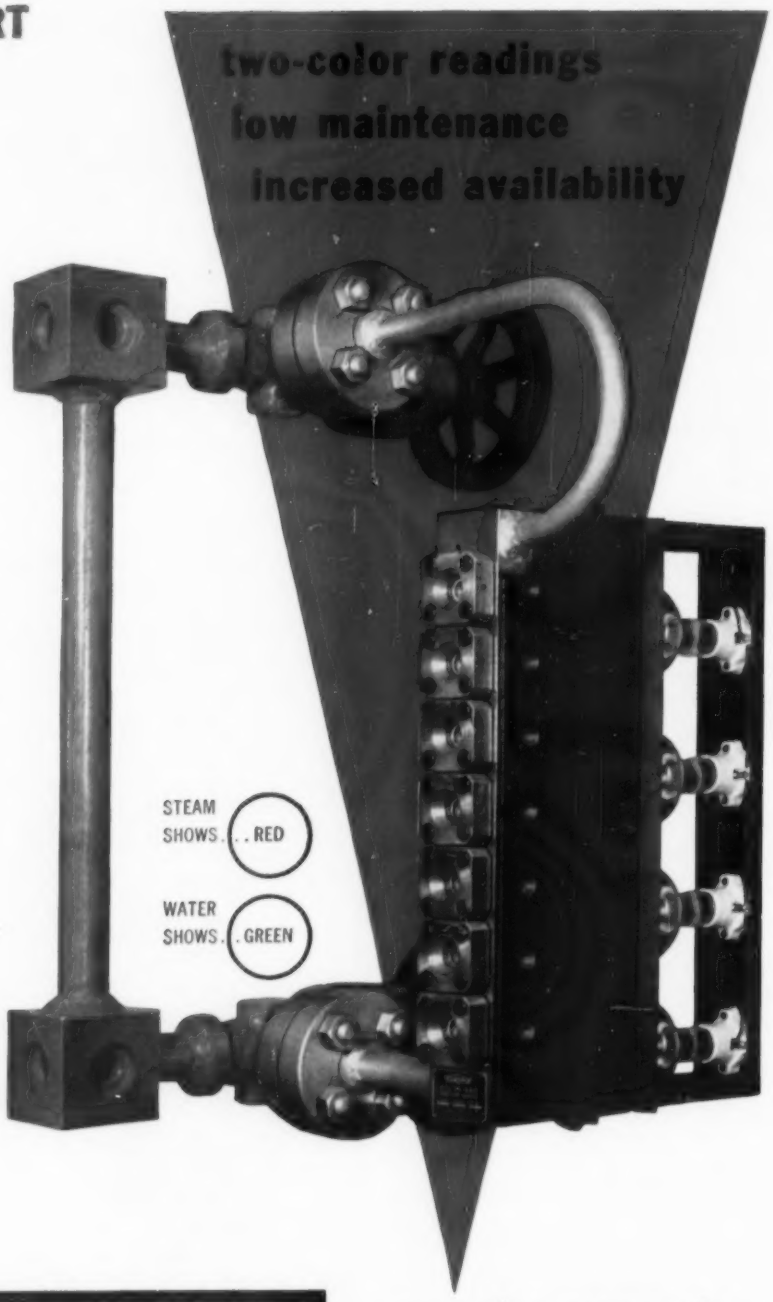

YARWAY COLOR-PORT . . . *a good way to specify high pressure water gages*

boiler water level indication?

YARWAY REMOTE LIQUID LEVEL INDICATORS

Boiler water levels and other liquid levels requiring remote indication can be handled completely by a Yarway system.

Heart of the system is the Yarway Remote Liquid Level Indicator that gives instant, accurate readings because the mechanism is operated by the boiler water or other liquid itself. The pointer mechanism is never under pressure. Clear, "wide vision" face permits easy readings from any angle.

The Yarway Indicator conforms with A.S.M.E. Boiler Code Committee ruling (Case #1155) permitting two independent remote level indicators of compensated manometric type to replace one of two required gage glasses for boiler pressures 900 psi and above.

Electronic Secondary Indicators can be added at any point in the plant. Remote Hi-Lo Alarm Signals (lights and/or horns) can be connected for additional safety.

Primary indicators fully compensated for every pressure change in boiler also available.

For permanent record of changing levels, the Yarway Hi-Lo-Graph Recorder can be furnished.

Over 10,000 Yarway Remote Indicators have already been installed. For full details, write for Yarway Bulletin WG-1824.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
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FULLY COMPENSATED INDICATORS

for completely accurate indication under every boiler operating condition.

ELECTRONIC SECONDARY INDICATORS

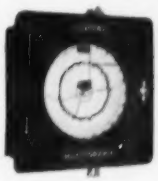
To supply additional indication at any point without pressure connections.

REMOTE SIGNALS

Hi Lo Alarms Lights and/or Horns

RECORDERS

To provide permanent 24-hour record of liquid levels.



YARWAY

. . . a good way to specify remote liquid level indicators

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Correct Lubrication in Action . . .

$13,388 saved in 6 months

Vulcanized Rubber and Plastics Company has been engaged for 75 years as a leader in precision molding and extrusion of hard and soft rubber—injection molded thermoplastic, and reinforced plastic parts for major industries and, in addition, is one of the world's largest manufacturers of combs.

Mobil **SOCONY MOBIL**

Leader in Lubrication for over 92 years

in the **Rubber and Plastics Molding Industry**

on maintenance, material, man-hours!

How the Vulcanized Rubber and Plastics Company made this substantial saving with the help of Socony Mobil!

In just six months the Vulcanized Rubber and Plastics Company has saved twice the total value of all its oils and greases purchased during the whole year of 1956! Beginning January, 1957, the company protected their Morrisville, Pennsylvania, plant with a Socony Mobil program of Correct Lubrication.

Plant engineer and Mobil lubrication specialists concentrated all their efforts towards improving efficiency of the plant's 42 hydraulic systems. Hydraulic fluids were standardized . . . filtering schedules set up . . . regular maintenance periods established. Periodic Mobil laboratory reports helped check oil quality and efficiency of filtration system.

Savings were swift and sizable. Downtime dropped sharply. Hundreds of repair and maintenance man-hours were eliminated . . . material costs cut. In total, $13,388 saved on the plant's hydraulic systems.

This is Correct Lubrication in Action. The cost-cutting program that devotes Mobil specialists, Mobil facilities, and Mobil's 92 years of lubrication experience to assure utmost protection and full service life from every Mobil product.

SUMMARY OF SAVINGS ACHIEVED THROUGH CORRECT LUBRICATION

* **$1,628 saved on hydraulic oils**—Following Mobil recommendations, plant replaced eight different hydraulic oils with only two Mobil products. This improved dispensing control . . . simplified reclamation . . . cut application time.

* **$2,400 saved on hydraulic system maintenance**—Before Mobil program, maintenance on hydraulic pumps, screens and valves in the injection molding department required two men on full-time basis. Program has proved so effective that equipment today requires only periodic inspection.

* **$100 per month saved on repair parts**—Prior to Mobil program, shafts on Vane-type pumps were snapping due to contaminants wedging into close-tolerance clearances. Cleaner oil and regular application under Mobil program eliminated problem . . . cut repair parts cost $600 in 6 months.

* **$8,760 recovered on press room operation**—Compared to same period in 1956, savings made in Vulcanized Rubber and Plastics Company's Press Room amounted to: $3,960 saved through elimination of downtime. $4,800 cut by reducing maintenance man-hours. Total—$8,760 saved in six months.

Correct Lubrication

A proved program to reduce manufacturing costs

SOCONY MOBIL OIL COMPANY, INC., and Affiliates: MAGNOLIA PETROLEUM CO., GENERAL PETROLEUM CORP., MOBIL OVERSEAS OIL CO., INC.

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POWER POINTERS

257,500,000,000,000 BTUs

SINCE INSTALLING ONE OF THE COUNTRY'S FIRST HIGH PRESSURE FEEDWATER HEATER SYSTEMS, AN EASTERN POWER PLANT HAS CONVERTED OVER 10¼ MILLION TONS OF COAL INTO BTU'S. YET NOT A SINGLE MONEL TUBE IN ANY OF THE HEATERS HAS BEEN REPLACED. HEATERS OPERATE AT 2000 PSI WATER PRESSURE, USE STEAM AT 900° F. STRONG MONEL* NICKEL-COPPER ALLOY RESISTS CORROSION, PERMITS USE OF RELATIVELY THIN-WALLED TUBING FOR MAXIMUM HEAT EXCHANGE.

¼ billion flexures in chlorinated water

...Monel check valve springs still springy

IN 1932, 3,450 MONEL CHECK VALVE SPRINGS WERE INSTALLED IN A METROPOLITAN WATER PLANT'S FOUR LARGE PUMPS. PREVIOUSLY, STRESS-CORROSION BECAUSE OF CHLORINE IN THE WATER CAUSED CRACKING AND FAILURE OF SPRINGS, SHORTENED THEIR LIFE TO 3 YEARS OR LESS. TODAY, OVER 90% OF THE ORIGINAL MONEL SPRINGS ARE STILL IN SERVICE, MANY AFTER 25 YEARS AND OVER A QUARTER BILLION FLEXURES.

The metal that comes back from Davy Jones' locker

MONEL ALLOY TAGS CLIPPED TO PUPS' FLIPPERS COME BACK FROM THE DEEP TO TELL A TALE OF THE MIGRATIONS OF SEAL HERDS. THE U.S. FISH AND WILDLIFE SERVICE FINDS MONEL ALLOY RETAINS IDENTIFYING MARKS FOR AS LONG AS 12 YEARS DESPITE SALT-WATER CORROSION AND ABRASION FROM ROCKS AND SAND.

Slowed down by a metal problem?

A TALK WITH ENGINEERS FROM INCO'S MECHANICAL ENGINEERING SECTION MAY HELP YOU GET BACK ON SCHEDULE. JUST GET IN TOUCH WITH US AND OUTLINE THE DETAILS. AND FOR A USEFUL RUN-DOWN ON MONEL ALLOY, WRITE DEPARTMENT **PE** FOR 30-PAGE INCO BULLETIN, "ENGINEERING PROPERTIES OF MONEL AND 'R' MONEL ALLOYS".

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York 5, N. Y.

INCO

*Registered trademark

INCO NICKEL ALLOYS

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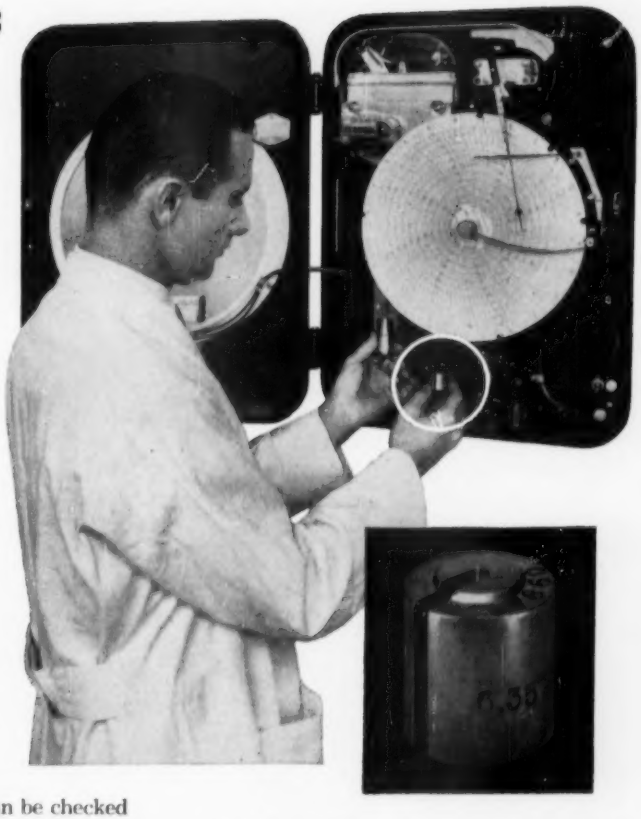
HAGAN RING BALANCE FEATURES—NO. 3

CHECK CALIBRATION OR CHANGE RANGE IN MINUTES

without water columns—without disconnecting meter from line



The calibration of any Hagan Ring Balance meter can be checked —in minutes—by simply hanging the appropriate weight on the check weight rod. Similarly, range change over a seven to one differential range can be done with equal speed and accuracy.

In terms of instrument technician's time, you can easily figure how much this one feature of the Ring Balance will save you. And, you don't have to take a busy pipefitter away from other work to break connections.

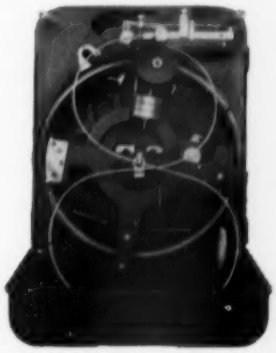
Ask your Hagan engineer to show you how easily range change and calibration checks can be made, using only the set of check weights supplied with each meter. Ask him, too, to explain some of these other outstanding features of the Hagan Ring Balance:

1. High sensitivity at low flows due to unique range calibration system. Full scale deflection at ½" WC.
2. Safe operation with rings rated at 2,500, 6,000, 15,000 psig. No gaskets, no stuffing boxes.
3. Sealing fluid density and level not critical. No eye-droppers.
4. Interchangeable ring assemblies for full scale ranges from 0.5" WC to 560" WC. Adjustment on any one ring over a seven to one differential range.
5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Pneumatic or electric transmission also available.

Bulletin MSP-141 describes these features and the new design of the Hagan Ring Balance meter case. ASK US FOR IT.

TIME SAVER—This shows how easily a Ring Balance can be checked. Note there are no two-story water columns—one man is doing the job—and the meter has not been disconnected from the line. In fact, Ring Balance can be checked at full static pressure if desirable.

The check weight is factory calibrated against a micrometer type manometer, and its equivalent in inches of water column is stamped on the side. The serial number of the meter to which it belongs is also stamped on the collar. A full set of calibrated weights is supplied with each meter.



Rear view of Ring Balance with cover plates removed. Here the test weights are in position on the test weight rod. Note accessibility of all parts for easy adjustment.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED
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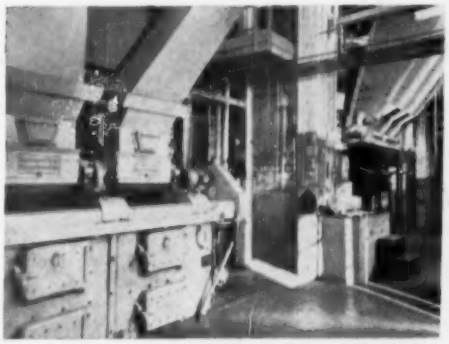
Carlisle Tire
CARLISLE TIRE

takes fuel costs for a ride

With increased fuel efficiency, Carlisle Tire and Rubber burns coal . . . holds costs to minimum while upping production 20%

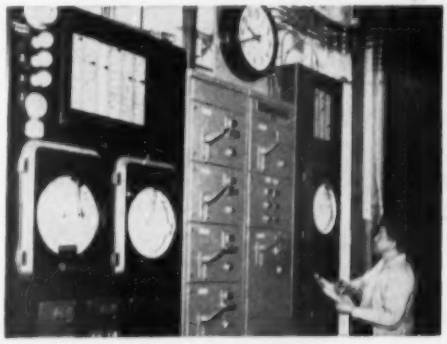
At the Carlisle Tire and Rubber Division of Carlisle Corp., Carlisle, Pa., the steam produced by the power plant is used primarily for processing. As production of bicycle tires, inner tubes and other rubber products increased, the firm's engineering department decided to boost steam capacity with modern coal-burning facilities. Coal was used on the basis of cost—25% less than the nearest competitive fuel. The result has been a dependable steam supply, cleanliness of operation and a jump in operating efficiency. Today the plant consumes the same tonnage of coal as before modernization although production has increased 20%!



Firing aisle of Carlisle's power plant. Left fore ground is new 20,000 lbs./hr. boiler by E. Keeler Co., fired by Detroit Rotostokers. In the rear is an Erie City Water Tube Boiler (equipped with Erie City Spreader Stokers), used as stand-by unit.

Facts you should know about coal

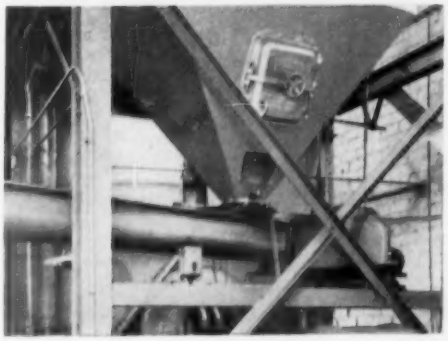
Not only is bituminous coal the lowest-cost fuel in most industrial areas, as in the case of Carlisle, but up-to-date coal burning equipment can give you 10% to 40% more steam per dollar on the average. Today's automatic equipment pares labor costs and eliminates smoke problems. And vast coal reserves plus mechanized production methods mean a constantly plentiful supply of coal at stable prices.



Close-up of control panel, by Hagan Corp. These controls—regulating furnace draft, steam flow, air flow, flue gas temperature, stoker control—constitute a complete, automatic combustion control system.

Technical advisory service

The Bituminous Coal Institute offers a free technical advisory service on industrial fuel problems. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to the address below. Or send the coupon below for our case history booklet, complete with data sheets. You'll find it informative.



Fly ash is collected by this Prat-Daniel Mechanical Precipitator. Fly ash is gravity-fed from the hopper (at top of photograph) into completely-enclosed screw conveyor which moves it cleanly to the disposal point.

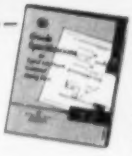
Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—will effect great savings for you in efficiency and fuel economy over the years.

BITUMINOUS COAL INSTITUTE

Southern Building • Washington 5, D.C.

The Bituminous Coal Institute now has available a free booklet, "Guide Specifications for Typical Low-Pressure Commercial Heating Plant," containing specifications, drawings and tables on all aspects of a typical heating plant. Send in this coupon for your copy.



Please send me: ☐ Guide Specifications booklet ☐ Case history booklet

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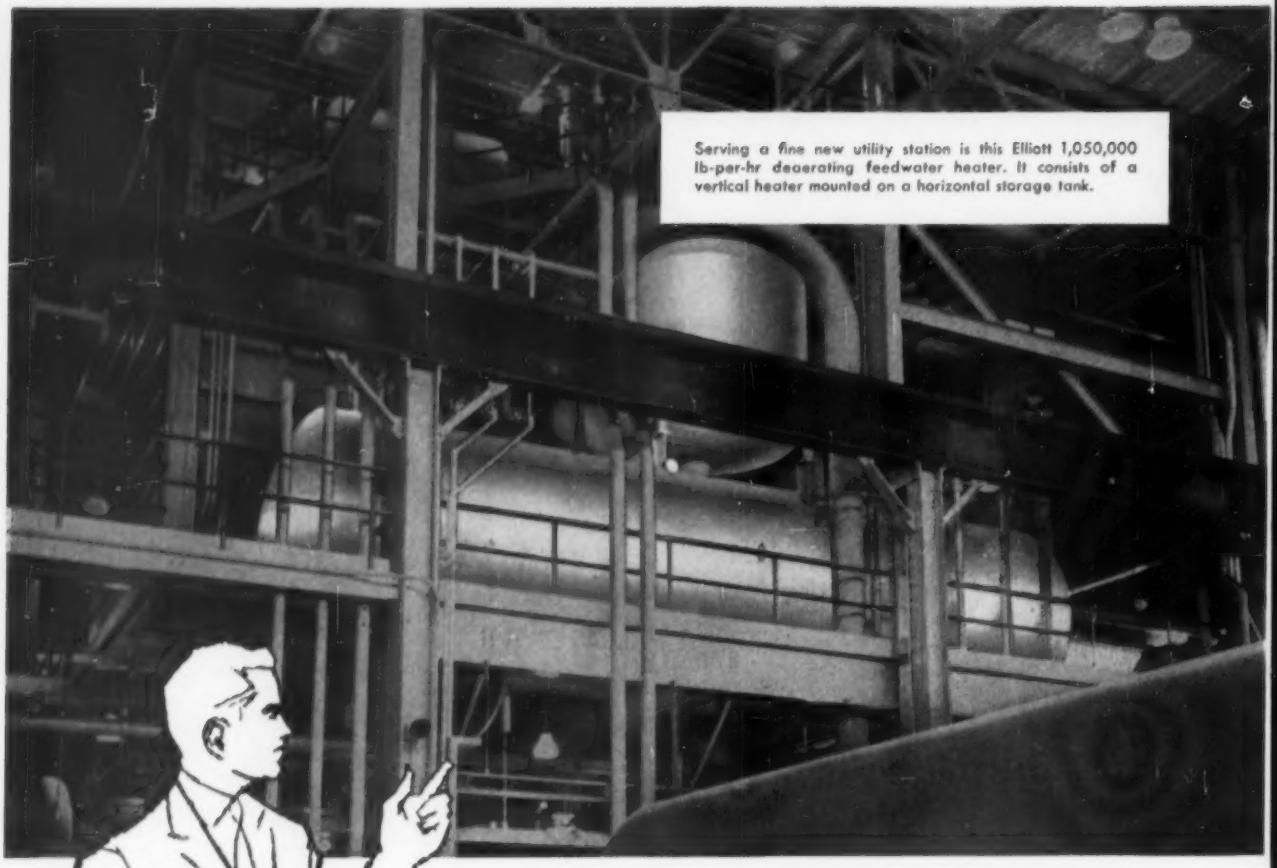


Serving a fine new utility station is this Elliott 1,050,000 lb-per-hr deaerating feedwater heater. It consists of a vertical heater mounted on a horizontal storage tank.

"These ELLIOTT deaerating heaters were designed to meet specific requirements and prevent corrosion to water-handling equipment"

For almost 40 years, Elliott has been designing and building deaerating feedwater heaters in all sizes . . . for small and medium-sized power plants up to giant heaters with a capacity of 2,500,000 lb per hr.

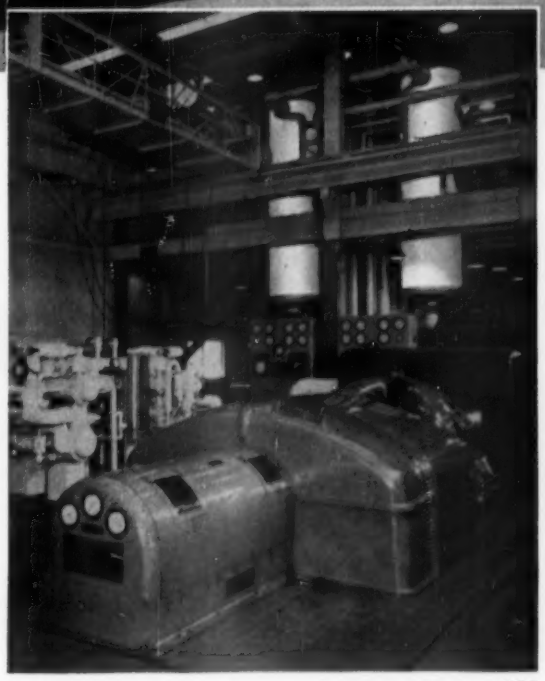
The heaters seen here illustrate Elliott's wide experience and versatility. They are engineered to remove corrosion-causing oxygen from boiler feedwater . . . meet individual thermal requirements . . . to be "tucked away" to fit the most confining space limitations . . . or for rugged outdoor service.

All Elliott deaerating heaters are made of the finest materials and good workmanship to insure the most economical, long-term, continuous performance. They are tops with utilities all over the country. Elliott heaters not only provide feedwater heated to the temperature of saturated steam, they also protect boiler tubes, piping, pumps and other water-handling equipment from damaging corrosion. The standard heater, equipped with an internal spray-type vent condenser, provides substantial savings in headroom and maintenance.

It pays to discuss your deaeration problems with Elliott engineers when planning new construction. For complete information write Elliott Company, Jeannette, Pa.

ELLIOTT Company

This weather-protected outdoor Elliott deaerating feedwater heater has 1,000,000 lb-per-hr capacity. At lower left is an Elliott 20,110 lb-per-hr evaporator preheater.



These two Elliott vertical deaerating feedwater heaters, each rated 40,000 lb per hr, serve a medium-sized plant. Shown also is one of two Elliott 3000-kw turbine-generators.

Ask for Bulletin N-18 on the Science of Deaeration

N7-2

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

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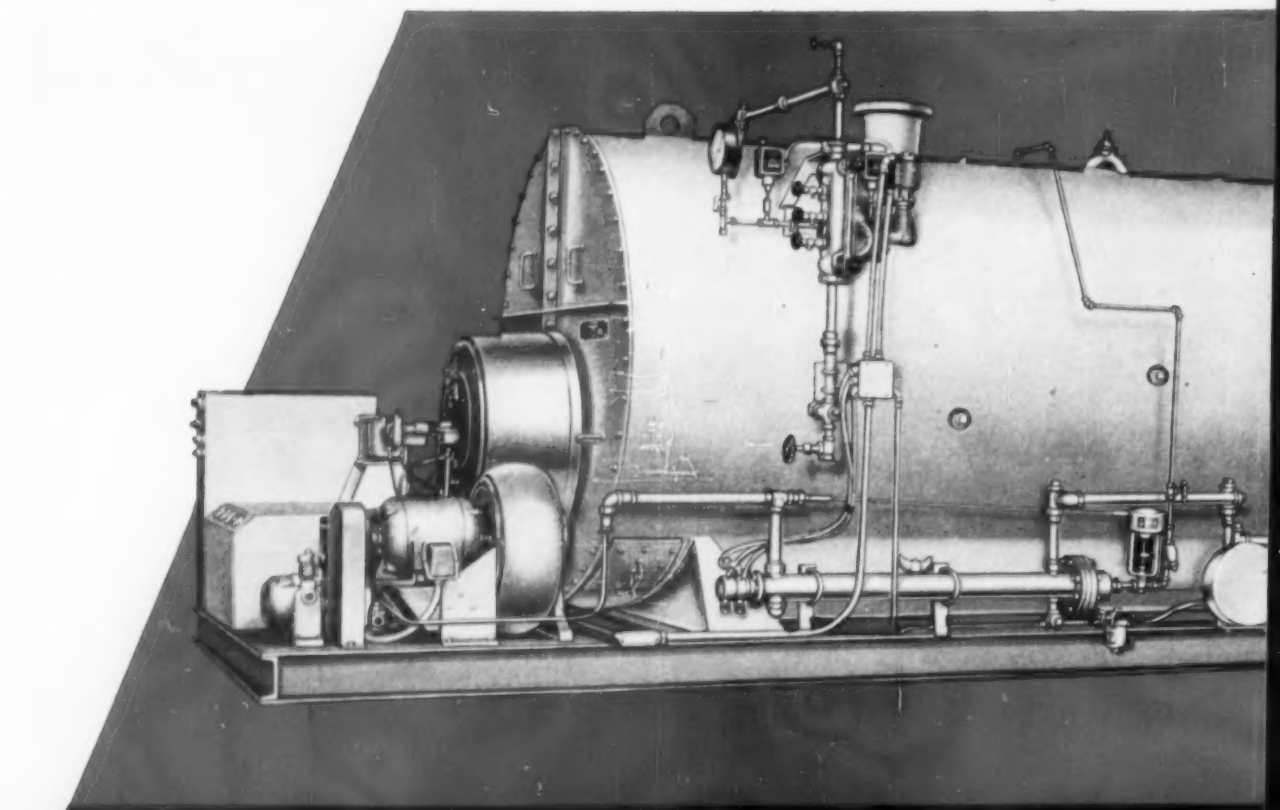
ERIE CITY FT

the small boiler package



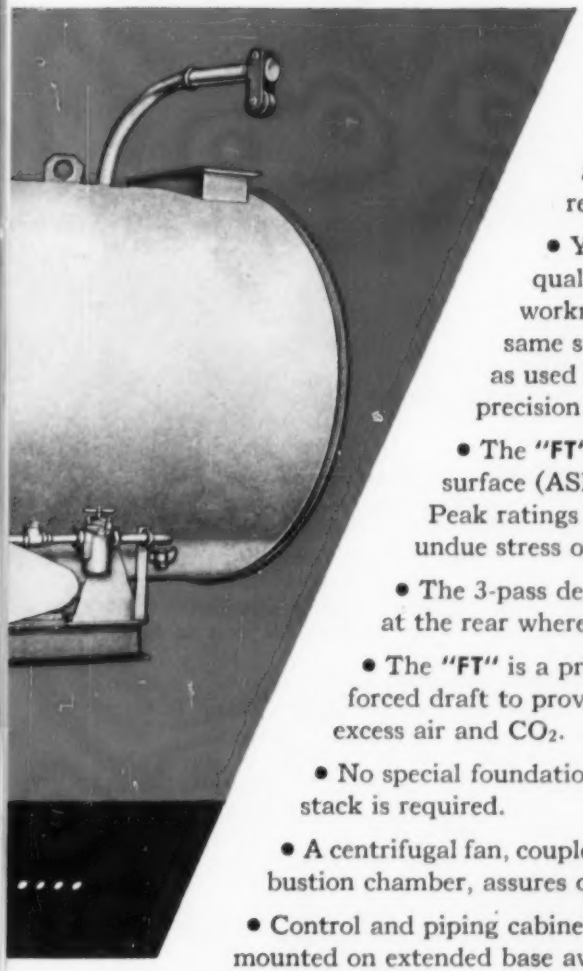
You can depend on Erie City for sound engineering

ERIE CITY
117 Years in Steam Generation

ERIE CITY IRON WORKS • *Erie, Pa.*

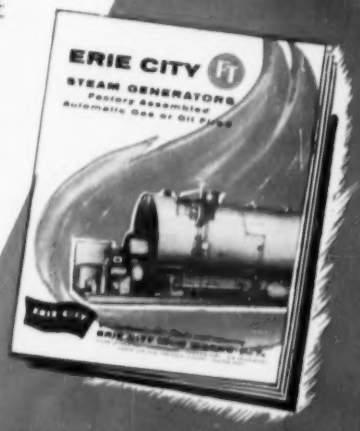
STEAM GENERATORS • SUPERHEATERS • ECONOMIZERS • AIR PREHEATERS
UNDERFEED AND SPREADER STOKERS • PULVERIZERS

for "PUSH BUTTON" steam with big boiler quality~~~



Backed by over a century of experience manufacturing high pressure water and fire tube boilers — the **"FT"** is manufactured, assembled, completely wired, piped and *factory fire tested*. It comes to you ready to go to work.

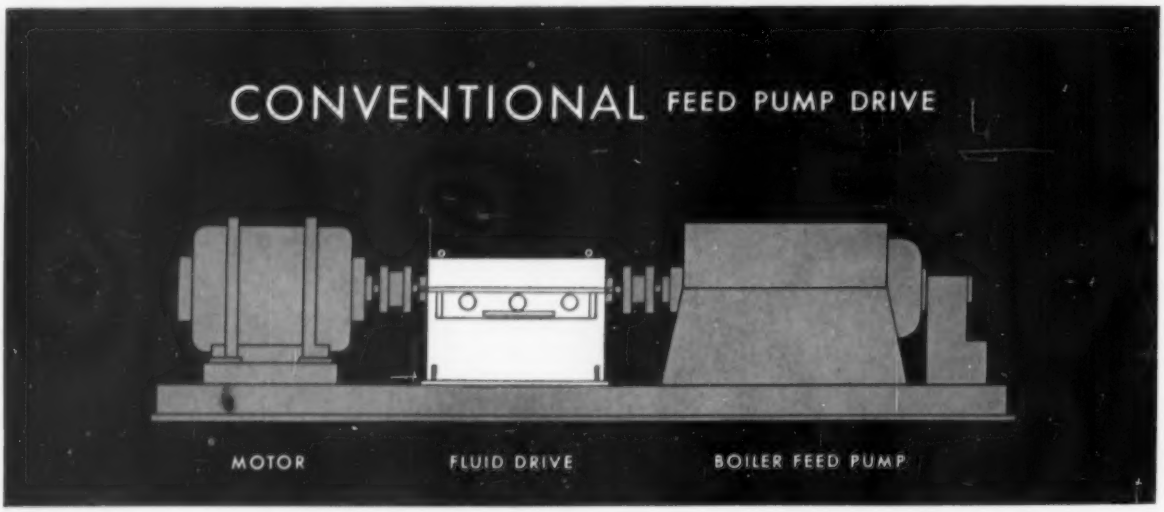
- You can be sure that the **"FT"** uses top quality materials — the same skilled workmanship — the same welding — the same stress-relieving and X-ray techniques as used on Erie City high pressure, precision built industrial power boilers.
- The **"FT"** has 5 full square feet of heating surface (ASME basis) per developed hp. Peak ratings are easily attainable with no undue stress on the boiler.
- The 3-pass design places the gas vent at the rear where it belongs.
- The **"FT"** is a pressurized unit using forced draft to provide precise control of excess air and CO_2.
- No special foundation nor expensive stack is required.
- A centrifugal fan, coupled to a closed combustion chamber, assures quiet operation.
- Control and piping cabinets are mounted on extended base away from heat and vibration.
- Every safety device is provided including indicating lights for "Power On"— "Ready"—"Pilot On" and "Main Flame."
- For the complete description of this top quality **"FT"** package that may cost a little more — but is worth it — write for SB-563L.

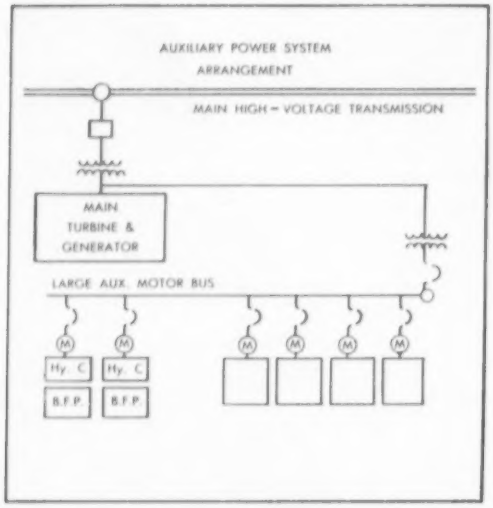


Did you send for your copy of CATALOG SB-563L

For more data circle 511 on Post Card

How *Gýrol*® Fluid Drive meets all

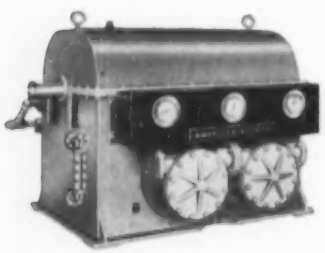




Of all power-plant auxiliaries, the boiler feed pump consumes the greatest single segment of invested power. To release more of this power to consumer lines, power plants of all sizes are controlling feed water flow by speed regulation through Gýrol Fluid Drive – driven by a constant speed prime mover.

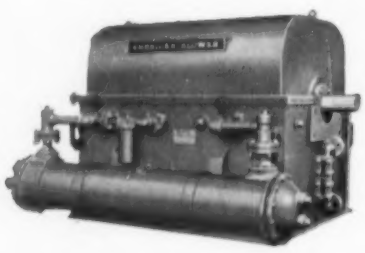
Gýrol Fluid Drive offers several specific advantages:

1. It saves power over the entire operating range by eliminating wasteful throttling by valves.
2. Fluid Drive's adjustable-speed feature permits reduction in pressure – resulting in further power savings.
3. It reduces wear on bearings, and other vital pump parts, by letting the pump operate at speeds that fit boiler demands.
4. With Fluid Drive, paralleling of pumps is simplified. Change-over from operating to standby pump is quick and easy.
5. Quiet operation is inherent in the design of Fluid Drive, since a "cushion of oil" is the means of energy transmission.



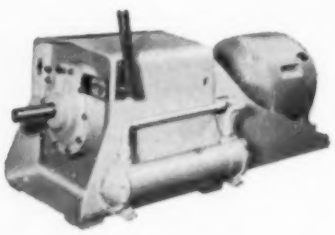
TYPE VS CLASS 6

- adjustable speed control
- 250 to 12,000 horsepower
- speeds to 3600 rpm



TYPE VS CLASS 4

- adjustable speed control
- 100 to 2500 horsepower
- speeds to 1800 rpm

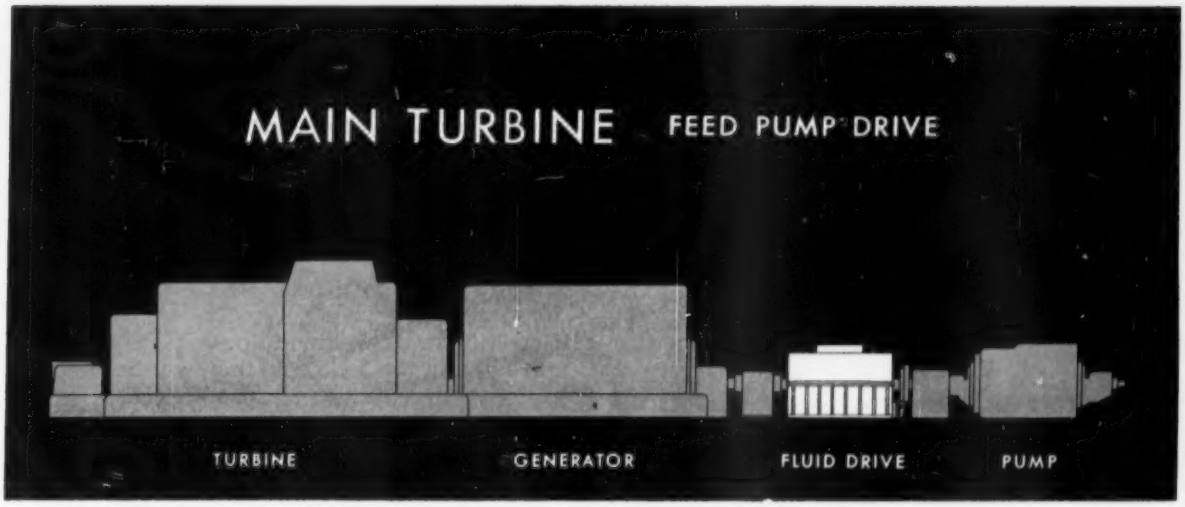


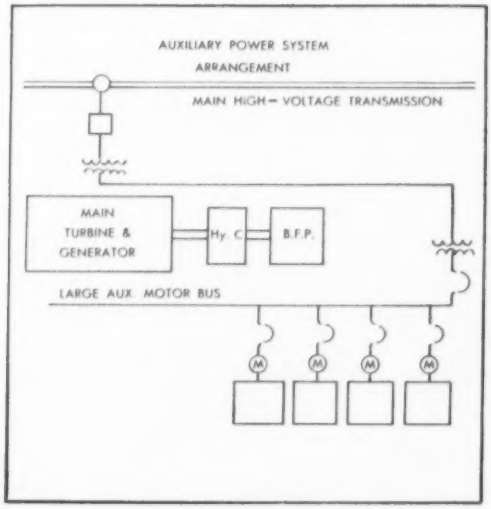
TYPE VS CLASS 2

- adjustable speed control
- 1 to 800 horsepower
- speeds to 1800 rpm

requirements for feed pump control

Regardless of station size, arrangement, or prime mover, you get the advantages of power savings, reduced pressures, and quiet operation with American Blower Gýrol Fluid Drives





Already in the construction stage is the use of Gýrol Fluid Drive for main turbine feed pump drives on some of the largest generating units yet projected.

For example, two of these stations will each drive, through a 12,000-hp adjustable-speed Gýrol Fluid Drive, the main feed pump from the high-pressure turbine. Full boiler capacities will be supplied by the single 5-stage pump, each delivering 6330 gpm against 6400 feet total discharge head when operating at 3510 rpm with feed water at 363° F.

Each pump requires an excess of 11,000 hp, and will be driven from the generator shaft through an adjustable-speed Gýrol Fluid Drive.

In your plans for expansion, why not discuss the advantages of Gýrol Fluid Drive with an American Blower engineer. His knowledge of this application in modern power plants may prove valuable to you. Call our nearest branch, or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

AMERICAN BLOWER

Division of AMERICAN-Standard

For more data circle 512 on Post Card

THE KVP COMPANY
Manufacturers and Converters of Paper
KALAMAZOO, MICHIGAN TEL. Fireside 3-2581

September 30, 1957

Mr. O. A. Soderberg
District Manager
Combustion Engineering, Inc.
1537 Book Building
Detroit 26, Michigan

Dear Al:

Nineteen months ago we placed boiler No. 9 in service. Since No. 9 is a C-E boiler, we thought you might be interested in the following information.

The paper industry is highly competitive and a difference of a fraction of a cent per pound of paper often means the difference between selling and not selling a customer. When it is considered that 11% of the manufacturing cost of our paper is power cost, it can be seen that any reduction in power cost has a real influence on the cost of the paper produced.

The installation of No. 9 boiler has contributed to reducing power costs in several ways.

(a) INCREASED EFFICIENCY

Boiler No. 9 replaced three existing boilers having an average efficiency of 78% with one boiler having an efficiency of 87.2%.

(b) REDUCTION IN FUEL COST

The three boilers replaced required coal having an ash fusion temperature above 2500 degrees F., whereas in No. 9 furnace we have burned, with no difficulty, coal having an ash fusion of 2100 degrees F. The ability of the boiler to use such coals opens up sources of coal supply hitherto unsuitable for our use, but which are now economically attractive.

(c) LOW MAINTENANCE AND HIGH AVAILABILITY

Maintenance costs to date have been very low. The boiler has been in operation nineteen months and the only outage for repairs occurred

Plants at KALAMAZOO, MICHIGAN
DEVON, PENNSYLVANIA
HOUSTON, TEXAS
STURGIS, MICHIGAN

ASSOCIATED COMPANIES of the KALAMAZOO VEGETABLE PARCHMENT COMPANY
THE KVP COMPANY LIMITED, Espanola, Ontario
APPLEFORD PAPER PRODUCTS LIMITED, Hamilton, Ontario and Montreal, Quebec

shortly after the unit was put in operation, when soot blower misalignment caused cutting of several tubes. Fortunately, this occurred at the end of the week when the boiler was taken off the line for a scheduled outage and our own maintenance crew made temporary repairs by seal welding the cuts. Shortly after, Combustion, at their own expense, replaced sections in six damaged tubes during a scheduled Sunday outage. This work required about eight hours and no production time was lost.

Each of the two pulverizers has handled over 50,000 tons of coal without maintenance other than minor adjustments.

(d) LIBERAL BOILER DESIGN

The ability of the boiler to handle sudden increases in load was demonstrated when it was called upon to pick up the load of one of the other boilers which was tripped off the line due to mechanical equipment failure. At that time No. 9 boiler output increased from 175,000 lbs. per hour to 230,000 lbs. per hour without difficulty and without interruption to manufacturing production. This load was 30% above the maximum continuous rating for which the boiler was designed. It may be of further interest to you to know that the liberal design of the boiler permits it to carry a load in excess of the above, the limiting factor being the capacity of the feed water valve.

As you may gather from the above, we are greatly pleased with this installation.

Sincerely yours

THE KVP COMPANY

Ed

Edward A. Wade
Project Engineer

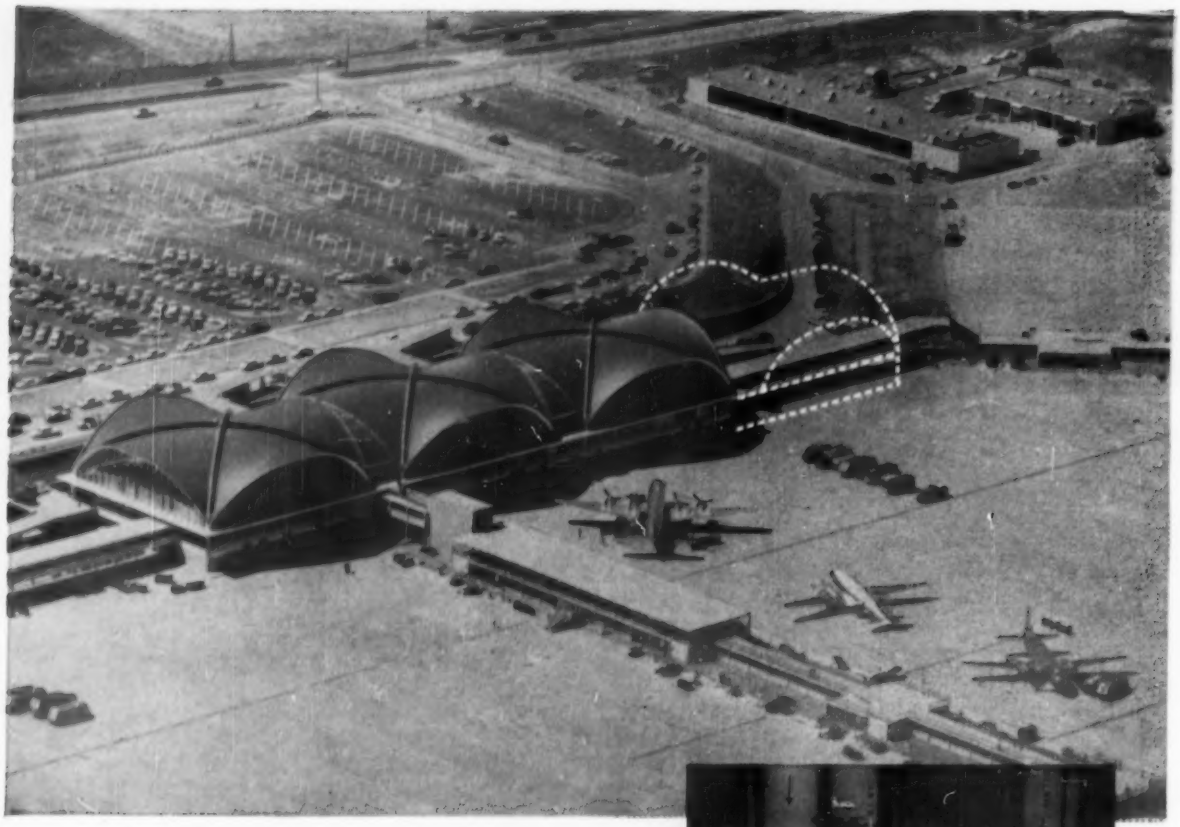
EAW:ss

COMBUSTION ENGINEERING, INC., Combustion Engineering Building, 200 Madison Avenue, New York, N. Y.

C-E
C-134

All Types of Steam Generating, Fuel Burning and Related Equipment, Nuclear Reactors, Paper Mill Equipment, Pulverizers, Flash Drying Equipment, Pressure Vessels, Soil Pipe

For more data circle 513 on Post Card



Nalco protects vital services of new LAMBERT-ST. LOUIS AIRPORT

Functional efficiency is usually one of the hallmarks of fine architecture and it is apparent throughout the new St. Louis Municipal Airport Terminal Buildings.

Vital service facilities are housed in a low, clean-lined power plant, well separated from the present main terminal building in anticipation of planned expansion to accommodate increasing airline traffic. The Nalco System protects boiler and cooling water systems by effectively controlling scale, corrosion and microbiological growth . . . a non-architectural supplement to functional efficiency in *any* plant where water is used.

Whether you are planning a new plant, or modernizing an old one, call on Nalco for water treatment chemicals and services that consistently produce outstanding results.

Top photo: Unusual modern architecture of St. Louis Municipal Airport Terminal Building is expandable in any direction. New units (dotted lines), can be added readily when required. Services buildings, *upper right*, are built and equipped with future expansion in mind. *Photo by Lloyd Spainhower.*

Lower photo: Nalco Chemicals and Services protect both boiler and cooling water systems at new St. Louis Airport. In this photo a Nalco cooling water treatment, supplied in ball briquette form, is being applied through the convenient Nalco feeder.

NATIONAL ALUMINATE CORPORATION

West 66th Place • Chicago 38, Illinois
CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA:
The Flox Company, Inc., Minneapolis 3, Minnesota
ITALY: Nalco Italiana, S.p.A.
WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

THE Nalco® SYSTEM . . . *Serving Industry through Practical Applied Science*

For more data circle 514 on Post Card

HELPFUL BULLETINS

ELECTRICAL

101 Vertical Motors — Bulletin 2050 presents "climatized" vertical hollow shaft motors for shallow- and deep-well turbine application. Advantages of the weather-protected enclosure are stressed and other construction features noted. Also explained are installation and maintenance time-reducing features. Specifications are provided, along with cutaway illustration of the motor. The Louis Allis Co.

102 D-C Motors, Generators — Form SB-182 describes d-c motors and generators, their general construction features, with cutaway illustrations. Included are dimensions and ratings from ½ to 200 hp on motors and ¾ to 200 kw on generators, with illustrations of typical applications. Marathon Electric Mfg. Corp.

103 Power Transformers — Advantages of company's "Preferred Design" power transformers are described in 40-pp Bulletin GEA-6604. Performance data, prices, outline drawings, dimensions and weights are given for typical ratings ranging from 5,000 to 50,000 kva, 69 to 138 kv, with or without load tap changing. Photos, drawings and dimensional diagrams illustrate the text. General Electric Co.

104 Open Dry-Type Transformers — Bulletin GEA-6668, 8 pp, describes open dry-type transformers, rated 300 kva and above, 15 kv and below, designed specifically to meet requirements of industrial use. Provides detailed explanation (with schematic diagram) of special silicone-treated core and coil structure, information concerning choice of three types of high-voltage terminations, weights and dimensions. General Electric Co.

105 Motor Control — The latest design features in company's front access, high voltage starters (Type H) for 2300 to 5000-v motors which provide maximum accessibility, protection, performance and space economy are given in 8-pp Bulletin 14 B8507. A cutaway view pin-points important features. Allis-Chalmers Mfg. Co.

106 Synchronous Motor Controls — Bulletin GEA-5873B, 8 pp, discusses features and applications of synchronous motor control; describes operation; and provides illustrated examples of how company's starters give step-by-step control of synchronous motors in all phases of operation. General Electric Co.

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Cards provided on pages 123 and 124.

107 Rugged Master Switch — Bulletin GEA-6706, 8 pp, provides detailed information on company's line of surface-mounted and desk-mounted heavy-duty master switches. Features, modifications, and operating advantages are discussed, and line drawings illustrating configurations included. General Electric Co.

108 Power Circuit Breakers — Bulletin GEA-6599, 8 pp, describes 69-kv power circuit breakers rated 1000, 1500 and 2500 mva, 600–1200 amp, and Bulletin GEA-6600, 8 pp, describes those rated 3500 and 5000 mva, 2000 amp. Each bulletin describes oil-blast interrupters that provide five-cycle interruption with low oil carbonization and reduced contact erosion. Included are curves, test and mechanism data, dimensions for floor or frame mounted designs. General Electric Co.

109 Control Panel — Bulletin GEA-6331A, 12 pp, discusses applications, engineering features, simplified maintenance procedures, and components of 30-in.-deep, front-connected Limitamp control panel. Table of weights and line drawings showing dimensions included. General Electric Co.

110 Self-Locking Connectors — Advantages of company's self-locking connectors are detailed in this 24-pp catalog. Features are illustrated with photos and drawings, and dimensional diagrams and specifications are included. Avnet Interlock Sales Corp.

111 Electrical Fittings, Fixtures — This hip-pocket size catalog features Alumalloy fittings and fixtures appearing in Condensed Catalog 57 (issued earlier this year). Illustrates styles, lists dimensions, and makes a handy reference guide. Killark Electric Mfg. Co.

112 Fluorescent Lamp Ballasts — Bulletin GET-922J, 16 pp, contains detailed data on types of fluorescent lamps, starters and ballasts. Complete information is included on installation and operation of ballasts, and equipment needed for d-c use. General Electric Co.

COMMUNICATION

113 Mobile Radio Equipment — Catalog 457, 40 pp, features company's two-way mobile radio antennas, accessories and towers. Profusely illustrated with photos, drawings and diagrams, bulletin includes electrical and mechanical specifications as well as horizontal and vertical patterns for antennas. Communication Products Co., Inc.

114 Two-Way Radio — Sixteen-pp Bulletin ECR-479 describes two-way radio communication for various commercial and industrial applications. Covers such matters as how far user can talk, licensing, dependability of equipment, and engineering, as well as adaptability, convertability and interchangeability. General Electric Co.

MECHANICAL POWER TRANSMISSION

115 On Flexible Shafts — Basic data on flexible shafts for remote control, power drive and coupling applications are given in 14-pp Bulletin 5601. Covers flexible shaft functions, advantages, nomenclature and characteristics. Selection factors are listed and discussed. A table shows torque transmitted at different horsepowers and speeds. Other sections of bulletin cover connecting flexible shafts, methods of attaching end fittings, use of integral formed drive squares and "do's and don'ts." S. S. White Industrial Division.

116 Electric Brakes, Clutches — Eight-pp Catalog Digest WEB-6292 describes company's electric brakes, clutches and controls for miniature mechanisms or high torque machine drives. Photos and drawings illustrate construction. Warner Electric Brake & Clutch Co.

117 Variable Speed V-Belts — Replacement Catalog VS-10, 32 pp, is designed to give complete cross-reference information on every variable speed v-belt for every type or make of unit. It also contains an alphabetical listing including drive data and part number listing of the manufacturers. The Dayton Rubber Co.

118 Improved Belting — Featured in this 12-pp catalog is a new type of power transmission belting made of polymer and chrome tanned leather, designed for superior strength and elimination of stretching. Sections of catalog cover significant applications, selection of proper belt type, tensioning and maintenance, and bearing load reduction. Extremultus, Inc.

119 High-Speed Belt — This 6-pp bulletin describes a transmission belt designed for speeds to 100,000 rpm and over. Includes detailed technical data, along with graphs showing results of competitive tests. Russell Mfg. Co.

120 Chains and Sprockets — Catalog 37 contains 30 pp of information on company's conveying and double-pitch power transmission chains and sprockets. Standard chain and attachments are illustrated and charts are used to provide pertinent engineering data for correct selection. Diamond Chain Co., Inc.

121 Bearings and Rod Ends — Features and engineering data on company's line of spherical bearings and rod ends are presented in 10-pp Catalog 257. Applications now in use and those under consideration by design engineers are detailed, and photos and dimensional diagrams are included. Sealmaster Bearing Div., Stephens-Adamson Mfg. Co.

122 Dihederal Spindle Couplings — Catalog 64, 12 pp, describes the development, production and application of company's dihederal spindle couplings for roller drives. Cross-section drawings and dimensional data are given on the various sizes and types of spindle couplings. Ajax Flexible Coupling Co. Inc.

123 Speed Reducers — Standard styles and sizes of double-reduction speed reducers in ratios ranging from 75:1 to 4900:1 are covered in 20-pp Catalog CD-230. Dimensional diagrams are included, as well as a specifications arrangement which makes it simple to select reducer of capacity and type desired. Cone-Drive Gears Div., Michigan Tool Co.

PACKINGS AND SEALS

124 Sheet Packings — Bulletin P-328, 8 pp, gives detailed specifications, engineering, application and testing data on

a complete line of industrial sheet packings. The packings covered are fabricated from such materials as asbestos, rubber, synthetic rubber, Neoprene, silicone, fiber and Teflon. Crane Packing Co.

125 Ring Seal — Information on use of the Quad-Ring, a four-lipped seal, is given in this 12-pp booklet. Illustrated with drawings and specification charts, booklet provides design considerations for reciprocal and rotary applications, an engineering check list for packing installation and material requirements and a listing of standard seal sizes. Illustrated case histories deal with solution of pressure sealing problems. Minnesota Rubber & Gasket Co.

VALVES AND PIPING

126 Ductile Iron Valves — Advantages of ductile, or nodular, iron valves are detailed in 6-pp Bulletin 572. Describes testing and research conducted in the development of the valves, as well as specifications on the valves and properties of the metal. Kennedy Valve Mfg. Co.

127 Gate Valves — The money-saving advantages of King-Clip gate valves are described in Circular 561. Illustrated with cutaway drawings and photos, bulletin gives detailed data, tables of steam and water-oil-gas pressure ratings, parts identification, and description of various metals and alloys used in their manufacture. Lunkenheimer Co.

128 Globe Valve Installation — Design, construction and testing of a new high pressure-temperature globe type valve for a utility generating station are discussed in the current issue of this company's house organ. Operating conditions at this station required that pressure drops be held below those of any globe valve previously built. Selection of the valve and other details of the project are described. Edward Valves, Inc.

129 For Air Operation — Advantages of Flo-Pilot valves for two or three-way air operation to 150 psi are detailed in 8-pp Catalog 262. Photos and drawings illustrating design features are included, as well as idea starters for control circuits. Hanna Engineering Works.

130 Emergency Cut-In Valves — Bulletin W-14 describes company's cushioned emergency cut-in valve which automatically opens to the emergency water supply when normal water supply is interrupted either from outage of electrical power or mechanical failure causing pump shut-down. Schematic drawings of installation, parts lists, dimensions included. Golden-Anderson Valve Specialty Co.

131 High-Vacuum Equipment — Valves, baffles and traps designed for high-vacuum applications are featured in 28-pp Bulletin 10-1. Explains design features and methods of operation, and includes selection tables, dimensional data, photos, drawings and diagrams. Consolidated Electrodynamics Corp.

132 Sizing Charts — Bulletin J-8C shows how to size company's sliding gate and plate regulator valves. Technical data (applying to all makes of valves) tells how to adjust sizing for variations in pressure, temperature, viscosity, specific gravity, etc. Charts cover steam, liquid and gas service. Jordan Corp.

133 Ways to Use Pipe — Application of ordinary pipe for hundreds of new industrial uses without necessity of threading, welding or of special tools is graphically presented in this 12-pp booklet. Explains how pipe can be used to save time and money as well as materials in fabricating or assembling a variety of special production fixtures. Tube-Strut Corp.

134 Method of Piping — This illustrated bulletin describes a method of joining thin wall steel and aluminum pipe and tubing by means of quick couplings assembled on grooves precision-rolled in the ends of the tubing. Details of the system and a variety of applications are covered. Victaulic Co. of America.

DUST CONTROL

135 Dust Collector — This 4-pp technical article covers a two-stage, cyclone-and-precipitator dust collection system. Includes photos of installation and explains how each unit operates. Buell Engineering Co., Inc.

136 Stack Sprays — BCR Aid to Industry 500-330 describes recommended procedures for reducing dust emission from boiler stacks during soot blowing and fire cleaning periods by using water sprays. Discusses amount of water required, selection and installation of stack spray nozzle, operation and automatic controls. Bituminous Coal Research, Inc.

INSTRUMENTS AND CONTROLS

137 Liquid Meters — Bulletin OG-412, 8 pp, describes liquid meters for measuring liquid propane, liquid butane and liquid propane-butane mixtures. In addition, it features an illustrated explanation of company's over-all dispensing system which insures liquid state of product throughout metering. Specifications and dimensions are tabulated and dimensional diagrams included. Meter and Valve Div., Rockwell Mfg. Co.

138 Liquid Level Gages — Condensed Catalog 305, 8 pp, illustrates and describes standard and special function gages and valves and gives dimensional drawings, construction features, pressure-temperature graphs and ratings, materials, and tables of sizes, specifications and standard and optional features. Jerguson Gage & Valve Co.

139 Compact Indicators — Bulletin MSP-121, 12 pp, presents a complete line of compact measuring instruments for draft, pressure, differential gas pressure and temperature. Includes installation data, clearance and cut-out dimensions. Hagan Corp.

You'll save time in ordering bulletins by using the Reader Service Cards on page 123. Of course we honor letterhead requests—but it takes us somewhat longer to handle them.

140 Valve Controls — How contraction or expansion of valve seat caused by decreasing or rising line temperature can be compensated for with company's valve controls is discussed in 6-pp Bulletin 4-57. Features of the valve controls are detailed and dimensional diagrams and ratings included. Philadelphia Gear Works, Inc.

141 Dial Thermometers — Bulletins 148, 149 and 150a describe bi-metal dial thermometers with back connected, bottom connected and "every angle" design for installation anywhere. Among other information, they include details on features, dimensions, and general specifications, photos and dimensional diagrams. Manning, Maxwell & Moore Inc.

LUBRICATION

143 Valve Lubrication — This 19-by-24 in. chart contains maintenance and lubrication information for company's lubricated plug valves. Of heavy paper with metal edges, the chart features detailed exploded views of four types of valves and includes a table of recommended lubricants for oil, water, gas and chemical service. Meter and Valve Div., Rockwell Mfg. Co.

144 Industrial Lubricants — This 16-pp booklet describes a wide range of tough lubrication jobs of industry and explains use of company's products in solving severe applications. Products are detailed as to type and application. Also shown and described are facilities and laboratories. The Brooks Oil Co.

WELDING, MACHINING

145 Welding Guide — Bulletin EW-201 contains 60 pp of useful arc welding information. Gives data on metals and electrodes, essentials of proper welding procedures, the fillet weld, types of joints, typical welding positions, welding symbols, standard steel shapes available, causes of common welding troubles and what to do about them, welding terminology, weight of weld metal deposited, spark tests by grinding, electrodes selection, types of electrodes, electrode identification key, explanation of AWS classification numbers, Hobart Bros. Co.

146 Cut-Machining Unit — This 8-pp bulletin describes the two types of the Roll-A-Round cut machining units — one power-operated. Shows their use in cutting thin wall steel, tube, cast iron water mains, rubber hose with steel core wires, Transite pipe, others. Wallace Supplies Mfg. Co.

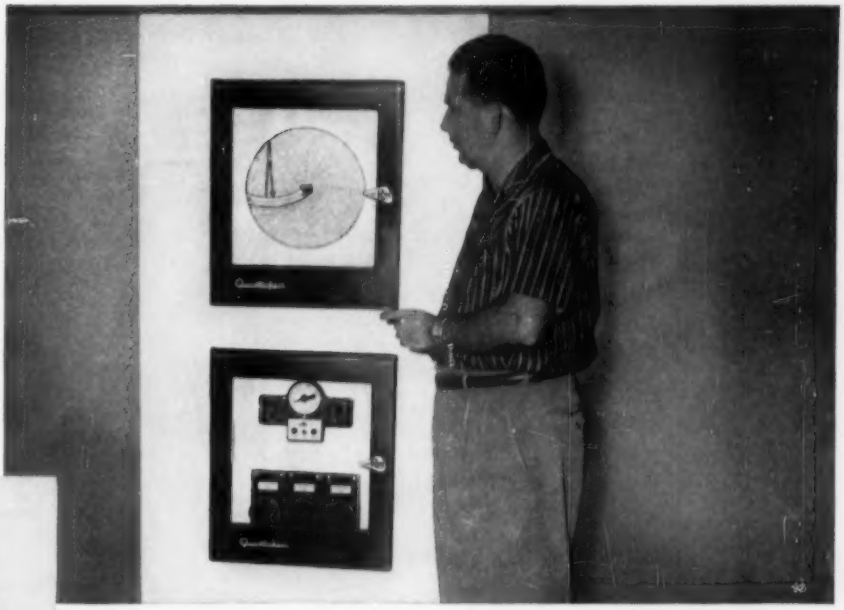
OTHER EQUIPMENT

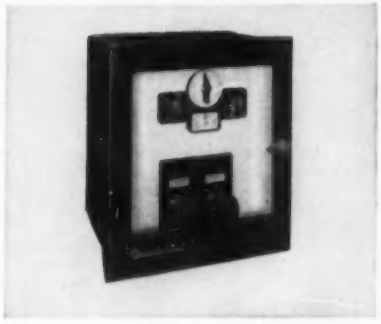
147 Belt Conveyor Equipment — Catalog 60-B, 15 pp, provides specialized data regarding the application of belt conveyors for the handling of materials, together with the listing of belt conveyor equipment. Included are charts and tables to assist in the selection of proper conveyor units and equipment for any specific service and location requirements. Webster Mfg., Inc.

148 Boiler Selection Survey — Six-pp Form SA-178 is designed to provide a means of selecting most suitable boiler for a particular application. Provides information on electrical supply, type of fuel to be used, boiler room size, special components or openings, boiler feed water, noise control, steam requirement estimate, and special instructions. Orr & Sembower, Inc.

149 Fastener Sealant Data — Technical Report 5 is a 12-pp illustrated discussion on Loctite sealant, a liquid lock for threaded fasteners. Tells what it is and how strong it is, and compares locking torque with that of locknuts and lockwashers. Properties are described and instructions for applying Loctite are given.

Quantichem automatic analyzers for total water hardness and dissolved silica concentrations include the electronic colorimetric unit and the recorder. These analyzers are especially important in the operation of water treating facilities for high-pressure steam power plants.





Automatically analyze water for silica and total hardness

...with the field-proven Quantichem instrument

All the steps of an analysis . . . from the flushing of sample cells and calibration of photoelectric measuring circuit to the metering of reagents and the recording of results . . . are performed by the new Milton Roy Quantichem instrument. This automatic analyzer is, in fact, a miniature lab for analyzing water for total hardness or silica content. Units are now in actual customer use after more than three years of research and field testing.

The silica analyzer has a range of 0 to 0.05 ppm . . . standard ranges for the total hardness analyzers are 0-3 and 0-5 ppm. Concentrations of other constituents in water, such as iron and phosphates, can also be analyzed by this unit. For these and other applications of this analyzer, consult our instrument engineers. Bulletin 1156 contains detailed information on the Quantichem instrument . . . write for your copy.

Suncoast Instrument Division, MILTON ROY COMPANY,
1300 E. Mermaid Lane, Philadelphia 18, Pa.

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CHEMICAL INSTRUMENTATION SYSTEMS

Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, Africa and Australia

For more data circle 515 on Post Card

ROTOJET®
Tube Cleaners

Clean tubes and pipes from ½" to 12" I.D. THOROUGHLY QUICKLY

ROTOJET Model 512 Air-driven Motor, universal joint, swing-frame head, and solid brush.

Our large stock of Rotojet air-driven and water-driven tube cleaners, accessories, and repair parts for straight and curved tubes, pipes, and transfer lines is available to meet most requirements without delay. Tube cleaner specialization for 43 years assures satisfactory results from any Rotojet equipment we recommend. Send for Bulletins J-410 and R-105. For quick action wire or phone, HUmboldt 3-0570.

ROTOJET Model C-526 Air-driven Motor with pivot head and universal joint.

ROTOJET Model C-525 Air-driven Motor with swing-frame head and universal joint.

ROTOJET Junior Model 532 Air-driven Motor, universal joint, cone cutter.

ROTOJET Junior Model C434 Air-driven Motor, flexible coupling, expanding brush.

ELLIOTT COMPANY – ROTO PLANT
DIVISION OF CARRIER CORPORATION
Tube Cleaner Specialists Since 1910

147 Sussex Avenue, Newark, N. J.

For more data circle 516 on Post Card

Information on applications provided. American Sealants Co.

150 Spark Ignition Engines — Eight-pp Form D755 outlines applications of manufacturer's recently introduced spark-ignition engines. These include pipeline pumping, industrial machinery powering, also use in powering sewage treatment plant in which the engines run on sewage gas. Includes detailed explanation of the engines' ignition systems. Caterpillar Tractor Co.

. . . Outstanding Among This Month's Catalogs

151 PVC Pipe — Dielectric values, power factor and volume resistivity of company's PVC pipe, along with mechanical and thermal properties, are explained in this 30-pp catalog. Describes general characteristics of PVC pipe, its properties, applications and gives installation data. An 8-pp chart classifies the corrosion resistance ratings of Type I and II PVC, low carbon steel, three classes of stainless, cast iron, aluminum, copper, red brass, lead, monel, and inconel with 383 chemicals. A. M. Byers Co.

152 How to Use Capacitors — Twelve-pp Bulletin GEA-5632B describes the why, where and how of industrial capacitor applications. Presents units and equipments available; discusses problems and solutions in selection of industrial capacitors and includes diagrams and pictures. A brief explanation of how capacitors lower power costs, release system capacity, improve voltage levels and reduce power losses is included. General Electric Co.

153 V-Belt Drives — Bulletin A661 is a 108-pp, comprehensive manual packed with information on selection and operation of V-belt drives. It is arranged in sections covering standard, variable speed and special drives, Taper-Lock sheaves, sealed-life V-belts, and Taper-Lock bushings and hubs. Engineering drawings and exploded views illustrate technical sections, which contain tables of pre-engineered drives, horsepower capacities, belt speeds, center distances, sheave diameters. This book is available to qualified power engineers; please state your job title when requesting this bulletin. Dodge Mfg. Corp.

154 Fire Alarm Systems — This 46-pp catalog contains revised and comprehensive data on all types of fire warning systems. Information covers systems for every type of property — from various types of institutions through office and industrial applications. Among the systems covered are selective code systems, general alarm systems, combination fire alarm and paging systems, remote station systems and other types of equipment and features. The Autocall Co.

155 Steam Heating Coils — Bulletin B-1418, 8 pp, describes double-tube steam distributing coils designed to distribute steam over entire coil-face area when steam supply is modulated for tem-

Neodesha packs 1-2 performance punch

1 | *Nordberg Diesels* 2 | *STANODIESEL Oil M*

Operator J. N. Finkinbinder (left) and Everett Powell, Neodesha Superintendent of Electric and Water Plants, adjust rocker arm assembly of Nordberg Duafuel Engine. Engine operated 40,431 hours before overhaul, carrying about 90% of load. All engines in service at Neodesha are Nordberg's. All use Standard Oil's STANODIESEL Oil M.

Finkinbinder and Powell inspect oil filter used for filtering STANODIESEL Oil M used in all six Nordberg Diesels at Neodesha, Kansas, power station.

Quick facts about STANODIESEL OIL M

- Keeps crankcase, pistons, cylinder walls clean.
- Combats deposit and wear problems imposed by using economy fuels.
- Maintains film on difficult to lubricate parts.
- Eliminates spark plug fouling in spark-ignited gas engines and reduces combustion chamber ash and deposits in engines burning natural gas, LPG and liquid fuels.
- Eliminates fuel injector and pump sticking caused by deposits on injector barrel and plunger where fuel and lube oil mix.

The city of Neodesha, Kansas, has six Nordberg engines in service. They have operated more than 400,000 hours on Standard Oil diesel lubricating oils. Here is the case story of one of these engines. The performance of this engine is typical.

In 1952, the city of Neodesha installed a 1,750 hp., 1230 kw., Nordberg Duafuel engine. During the period between February 14, 1952, when the engine went into service, and March 1, 1956, the engine ran 34,370 hours out of a possible 35,784. This is 96% of the engine's total installed hours. In this time, not even a piston or cylinder head was removed. So good was the performance of this engine using STANDARD HD Oil that when Standard introduced an improved diesel oil—STANODIESEL Oil M—in February, 1955, this engine was converted to this new oil.

There is more to the story. The engine continued in service to 36,223 hours when No. 7 cylinder liner was pulled to put rubber gaskets on liner to stop water leakage. At this time, No. 7 piston and liner were checked. Liner wear averaged only 0.0045 inches. The top ring showed an average wear of 0.016 inches. The No. 2 ring was 0.020 inches. Little, if any, wear was indicated on other rings. Now, at 40,431 hours, the engine is down for overhaul of turbocharger and to have valves ground. Bearings were found in excellent condition. No pistons are to be pulled.

Get more facts about STANODIESEL Oil M by calling the Standard Oil office near you in any of the 15 Midwest and Rocky Mountain states. Or write Standard Oil Company, 910 S. Michigan Ave., Chicago 80, Illinois.

STANDARD

STANDARD OIL COMPANY
(Indiana)

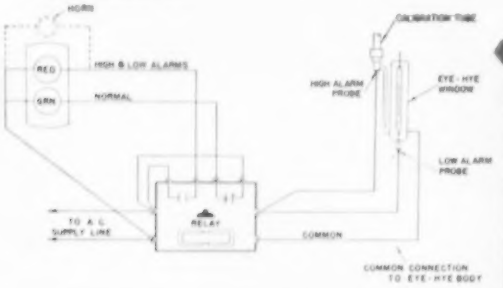
Why not *triple* your boiler water level safety!

Remote reading Reliance EYE-HYE gives you extra sound and sight alarms when you add the Levalarm

Improve the safety of water level supervision *even more* than EYE-HYE's recognized remote reading advantages; add *extra alarms* at small cost. Reliance electrode Levalarm EA9 augments the illuminated sharp-reading EYE-HYE with vibratory horns or signal lights, or both. They work instantly to alert operators when water levels reach danger points.

The boiler water itself calls the signals! Stainless steel electrodes with teflon insulation pick up a tiny current. Sensitive relays make or break independent circuits that operate the alarms. Levalarms work on low pressure or high.

Reliance Light Indicators, 2-light or 3-light, show green for normal water level — red for dangerous low or high condition. Horns are sturdy noise producers that demand action . . . Low alarm Levalarm can be installed on most EYE-HYEs in service. High alarm facility must be added at our factory. Send EYE-HYE serial number and ask for catalog section C6.

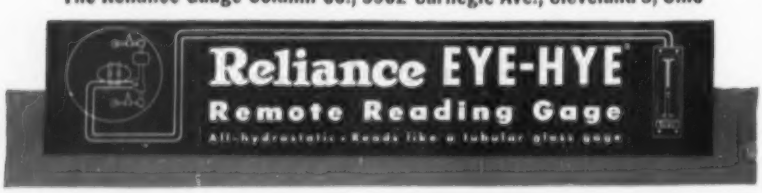


Wiring diagram for high and low alarm hook-up with 2-light indicator and/or horn.

Example of compact hook-up—EYE-HYE with horn and 2-light indicator. The extra signals can be placed any desired distance from the EYE-HYE.

Electrodes used in Levalarm EA9 withstand effects of high temperatures. Require no adjustment.

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio



For more data circle 518 on Post Card

perature control. Gives physical data illustrated with an installation type drawing, as well as selection data, tables on final air temperature, temperature rise correction factors, air friction tables, piping instructions and diagrams. American Blower, Div. of American Standard.

156 Sludge Dispersal — Advantages of sludge dispersal and disintegration in storage tanks and equipment are explained in Bulletin FO-157. Treatment is described which dissolves sludge into combustible material and emulsifies condensate water as a protection against rust and corrosion. The North American Mogul Products Co.

157 Saturable Power Reactors — Bulletin F-8383 is a 32-pp application guide for the use of saturable power reactors. Discusses turn down characteristics and the application of automatic control to these units. Typical curves showing characteristics are included, as well as wiring diagrams and other data. Barber-Colman Co.

158 Standby Power Sets — This bulletin details merits of emergency electric power plants and shows standard models available. Controls and panel equipment are listed also, and tips on selection of standby plant given. Katolight Corp.

159 For Water Distillation — Three types of water evaporators, including vapor compression apparatus, flash evaporator and centrifugal compression still, are illustrated and described in this 8-pp bulletin. Lists models and capacities, weight, space requirements and other data, and includes flow sheets, diagrammatic material and photos. Badger Mfg. Co.

160 For Rust Removal — The properties and uses of the recently introduced powdered acid scale and rust remover are described in this service report. Advantages are discussed and recommended solution concentrations and application methods given. Oakite Products, Inc.

161 Instrument Air Dryers — Bulletin 857 describes design features and operation of adsorptive type, automatically regenerated instrument air dryers with capacities to 125 standard cfm at 90 F and 100 psig. Contains complete specifications including a sizing nomograph. Anders-Lykens Corp., Div. of Milton Roy Co.

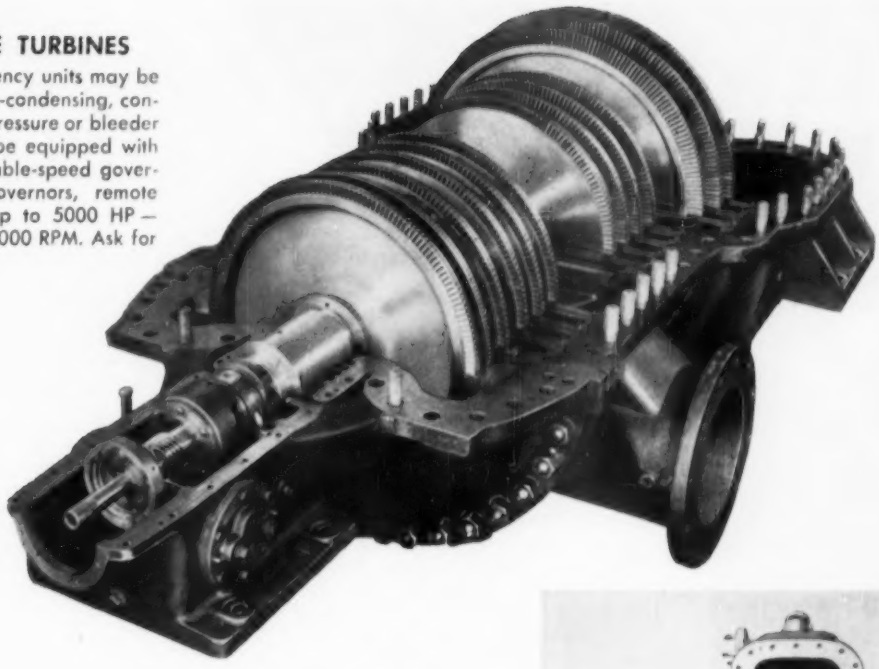
162 Color Code Chart — This handy, durable chart contains color codes and calibration symbols for thermocouples and thermocouple extension wires plus pyrometer wire resistance figures. Thermo Electric Co., Inc.

163 Filter Cloth Selection — Bulletin 10, 8 pp, gives complete technical data on all types of filter cloth, including Nylon, Dacron, Vincel, Orlon, Dynel, Teflon, Saran, cotton, glass, polyethylene and special filter papers. Data covers chemical resistance, corrosion resistance, abrasion resistance and available yarn forms for each type of cloth. The National Filter Media Corp.

164 Nuclear Radiation Facilities — Power engineers concerned with any aspect of nuclear radiation will find in Form G-717-1 a presentation of this company's services. They cover irradiation, performance testing, analysis and prediction of radiation effects, others. Nuclear Radiation Lab., Admiral Corp.

MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

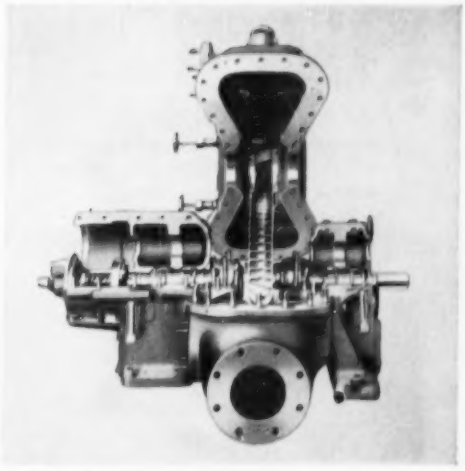
The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

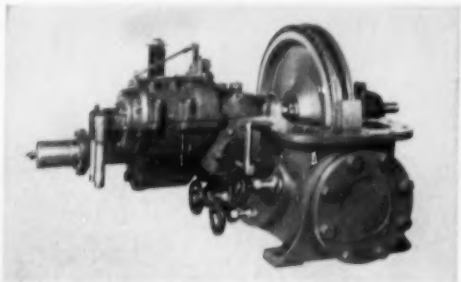
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TERRY



SOLID-WHEEL TURBINES

Famous for sure dependability and ease of inspection. Can be started cold — no preliminary warming required. Available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.



AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.

TT-1209

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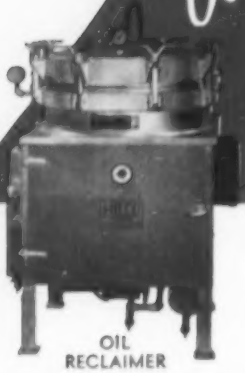
HILCO OIL RECLAIMERS

REMOVE WATER, SLUDGE, ACID

for complete

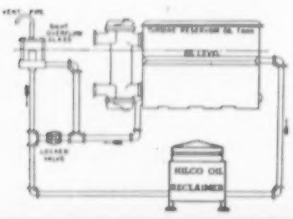
TURBINE OIL CONDITIONING...

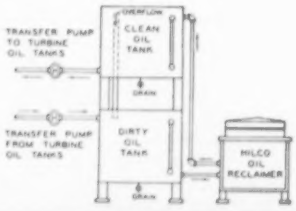


OIL RECLAIMER

The HILCO Turbine Oil Reclaimer is a self-contained, compact unit that will produce and maintain oil free of all solids, sludge, acids, moisture and air, keeping the oil in first class condition. Its purifying process is a continuous, all electric, automatic operation, requiring infrequent attention. It removes contaminants as fast as they are formed, maintaining lubricating oil at full value of new oil. HILCO Oil Reclaimers will also purify compressor, hydraulic, insulating, Diesel and gas engine lube oils.

Purifies Turbine Oil by Continuous or Batch Purification . . .




TRANSFER PUMP TO TURBINE OIL TANKS
CLEAN OIL TANK
TRANSFER PUMP FROM TURBINE OIL TANKS
DIRTY OIL TANK
HILCO OIL RECLAIMER

★

★ WRITE FOR THIS FREE BOOKLET TODAY . . . FOR MORE INFORMATION ON HILCO TURBINE OIL RECLAIMERS . . .

THE HILLIARD Corporation

162 W. FOURTH STREET ELMIRA, N. Y.

"IN CANADA: Upton-Bradeen-James Ltd., 890 Yonge St., Toronto; 8760 Verville St., Montreal

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Technological Revolution By Year 2000

A TREMENDOUS revolution will have taken place by the year 2000. Rather than political, the revolutionaries will be scientists and engineers whose record in the past well justifies their key role in our future.

Scientific advances made since the turn of the century provide some basis for this forecast made by Dr. H. J. Rand, president of the Rand Development Corp, at a recent research and development conference of the American Management Association.

Progress is not now moving along a straight upward curve but rather exploding in logarithmic fashion. For example, half of all the oil consumed by man has been consumed in the last 25 years; the Strategic Air Command can drop in one raid more explosive power than was expended in all of World War II by all military forces; the speed of the airplane has increased from a little over 100 miles an hour to 2000 mph since 1910; and rockets which might in the near future be manned by man have exceeded 3000 mph.

Dr. Rand predicts that leaders in the revolution will be Chemistry, Plastics, Metallurgy and Electronics. Plastics with tremendous tensile strength and heat-resistant inorganic fibers will provide us with the means to achieve new speeds; new discoveries are enabling man to change the nature of the elements for his use.

In the field of energy requirements, Dr. Rand said that by the year 2000 we will be very much aware of the limited amounts of cheap fossil fuels available, atomic energy will be commonplace. Control of atomic fusion, the hydrogen bomb reaction, is approaching.

He predicted that farmers will control tractors from a central station where they watch TV screens to guide their machines. Progress in scientific breeding will continue to improve the animals we use for food.

Man's ability to solve difficult problems is being enhanced a thousandfold by electronic brains and computors. Dr. Rand called these devices the key to man's ability to grapple successfully with the technological revolution he is creating.

We can expect to see electronic brains controlled by pre-set instructions in nearly every factory, farm, government office, school, and even in the home.

In keeping informed on the new trends, Dr. Rand suggested that management might seek free technical advice in areas such as metallurgy and plastics, which are moving the fastest.

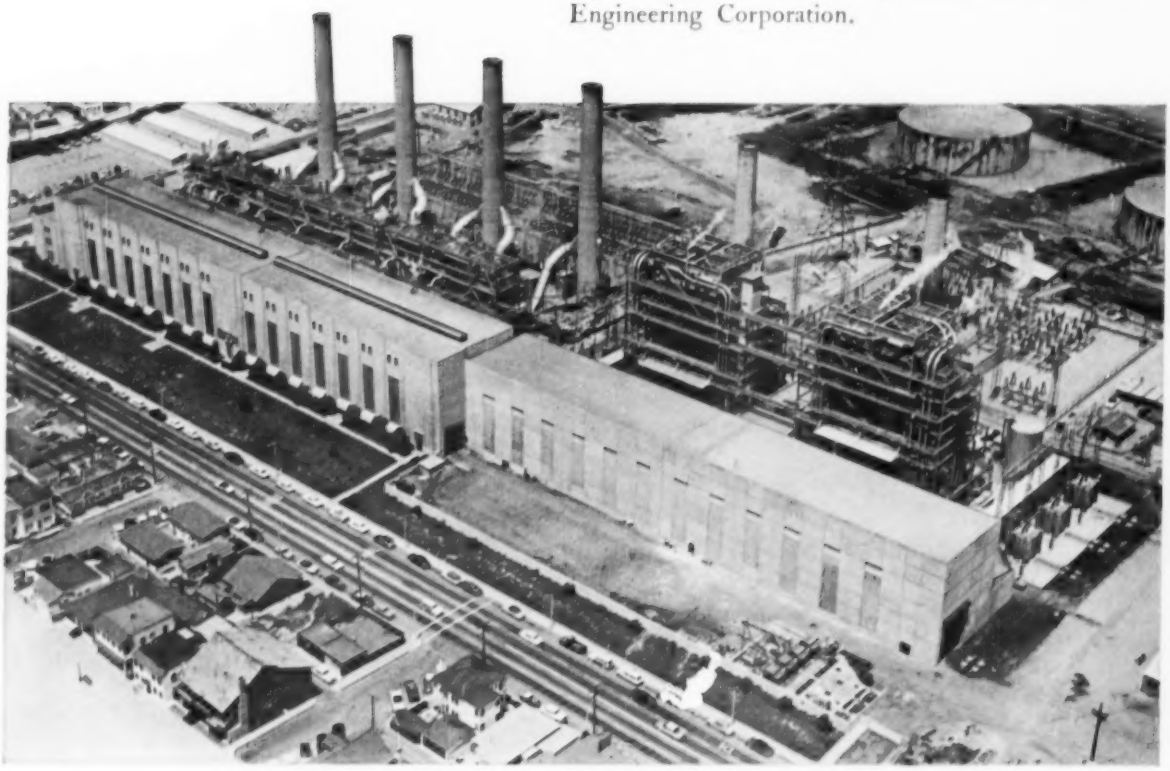
Try fresh approaches to old problems, specialize in narrow fields; don't set too rigid a course and steer for oblivion, he warned.

RETURN TO REDONDO

Unit #6 of the Redondo Steam Station of the Southern California Edison Company went into commercial operation less than 22 months from the time Stone & Webster Engineering Corporation received authorization to proceed with design and construction.

This unit with a capacity of over 150,000 kw was designed to operate on gas and/or oil. Complete remote controlled furnace ignition and combustion control permits firing of Units #5 and #6 by either fuel from a centralized control room.

A second control room serves Units #1 through #4 in a similar manner. Together they permit effortless operation over a wide range of load at minimum operating cost. All six units were designed and constructed by Stone & Webster Engineering Corporation.



Write or call us for information as to how our experience may be of assistance to you.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY *of* STONE & WEBSTER, INC.

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

Bailey Meters and Controls for Combustion, Feed Water, Steam Temperature and Condensate at Moores Park Station, City of Lansing, Michigan.

How Bailey makes steam operating duties a pleasure—

Fingertip Controls, convenient indicators and trend recorders make steam control room operating duties a pleasure. You get this bonus for your operators when you specify Bailey Meters and Controls.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. A Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs.

Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A133-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1040 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

Now . . . Electronically Tested Condenser Tubes from Bridgeport

In addition to regular ASTM specification tests, Bridgeport Condenser Tubes may now be checked by ultra-sensitive, electronic tube inspection equipment. These modern nondestructive testing devices check each tube to insure that it is free from flaws, cracks, seams and slivers—differences in cross-sectional dimensions and chemical composition.

This testing method is fast and accurate. It eliminates human errors. In operation, the tubes pass through a magnetic field at a uniform speed. Flaws in the tube, which interrupt the pattern of the field, are instantly sensed by an electronic detector which signals acceptance through an oscilloscope and by audio and visual signals.

Electronic testing is just one of many fabricating and testing procedures used by Bridgeport to maintain its high standards of quality and workmanship and to give you better, more economical tube performance. It's in keeping with the requirements that must be met in today's increasingly critical operations.

Make use of Bridgeport's long experience and thorough familiarity with the manufacturing of condenser and heat exchanger tubes. Call your nearest Bridgeport Sales Office on your Copper, Admiralty, Aluminum Bronze, Aluminum Brass, Cupro Nickel, Duplex or other tube requirements.

Bridgeport Brass Co.

BRIDGEPORT CONDENSER TUBES

Bridgeport Brass Company, Bridgeport 2, Conn. • Sales Offices in Principal Cities

In Canada: Noranda Copper and Brass Limited, Montreal

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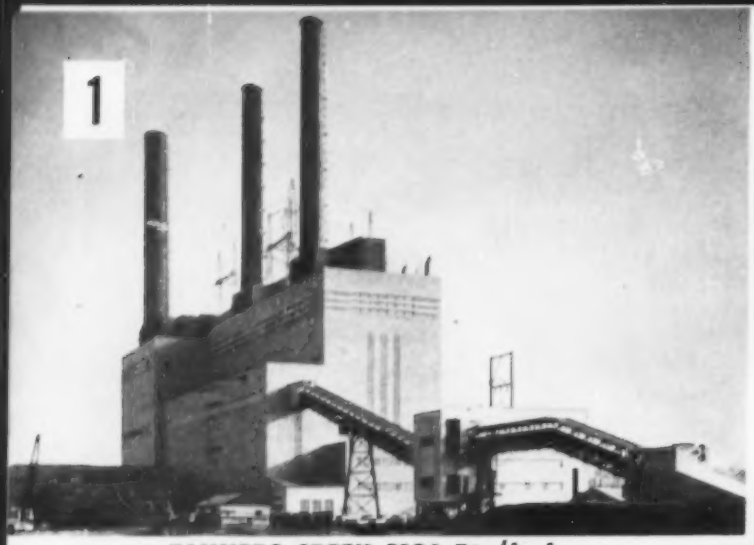
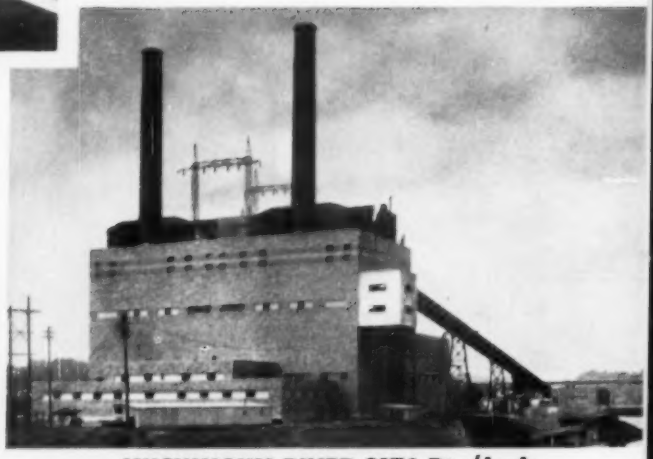


TANNERS CREEK 9106 Btu/kwhr
Indiana & Michigan Electric Co. on the American Gas and Electric System
Three B&W Pressure-Fired Radiant Reheat Boilers

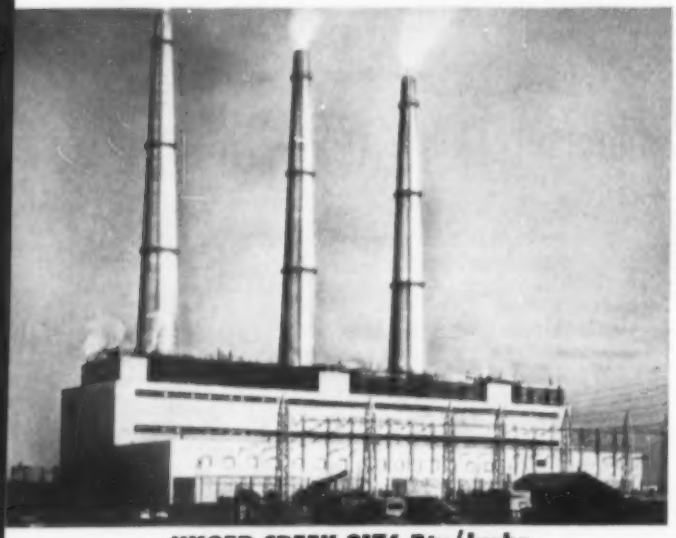
MOST EFFICIENT HEAT RATES IN THE POWER INDUSTRY



MUSKINGUM RIVER 9176 Btu/kwhr
Ohio Power Co. on the American Gas and Electric System
Two B&W Pressure-Fired Open-Pass Reheat Boilers

KANAWHA RIVER 9115 Btu/kwhr
Appalachian Electric Power Co. on the American Gas and Electric System
Two B&W Pressure-Fired Radiant Reheat Boilers

CLIFTY CREEK 9200 Btu/kwhr
Indiana-Kentucky Electric Corporation†
Six B&W Pressure-Fired Open-Pass Reheat Boilers



KYGER CREEK 9176 Btu/kwhr
Ohio Valley Electric Corporation†
Five B&W Pressure-Fired Open-Pass Reheat Boilers

JOHN SEVIER 9221 Btu/kwhr
Tennessee Valley Authority

ST. CLAIR 9200 Btu/kwhr
Detroit Edison Co.
Four B&W Radiant Reheat Boilers

SHAWVILLE 9241 Btu/kwhr
Pennsylvania Electric Co.
Two B&W Radiant Reheat Boilers

RIVER ROUGE 9210 Btu/kwhr
Detroit Edison Co.
One B&W Radiant Reheat Boiler

BAY SHORE 9282 Btu/kwhr
Toledo Edison Company
One B&W Radiant Reheat Boiler

B&W Engineering Developments Pay Off in Power Plant Efficiency

Nine Out of Nation's Top Ten Have B&W Boilers

Here are the ten most efficient power plants in the United States in 1956 as reported by the Federal Power Commission. Their achievement reflects the signal success of the power industry in keeping electricity America's best bargain despite rising fuel and other costs.

A major investment in engineering research and development has made possible these great strides in power plant efficiency. Six years ago only two plants operated under 10,000 Btu per net kwhr. In 1956 there were no less than 47. In addition a great many new units incorporated in older plants are now operating at these high efficiencies. It is significant that nine out of the nation's top ten plants in terms of efficiency are equipped with B&W boilers.

B&W's role in this vital industry has been a crucial one, covering nearly a century of boiler engineering, design and fabrication. Today, millions of dollars are being invested in major B&W engineering developments—such as the Universal Pressure Boiler, utilization of low grade fuels, basic metallurgical research for high temperatures, and nuclear energy—all to help America's utilities continue to supply abundant, economical, reliable electricity. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

G-877-C5

† Ohio Valley Electric Corporation and its subsidiary, Indiana-Kentucky Electric Corporation, sponsored by these companies:

Appalachian Electric Power Company* • The Cincinnati Gas & Electric Company Columbus and Southern Ohio Electric Company • The Dayton Power and Light Company • Indiana & Michigan Electric Company* • Kentucky Utilities Company • Louisville Gas and Electric Company • Monongahela Power Company** Ohio Edison Company • Ohio Power Company* • Pennsylvania Power Company*** • The Potomac Edison Company** • Southern Indiana Gas and Electric Company • The Toledo Edison Company • West Penn Power Company**

*Subsidiary of American Gas and Electric Co. **Subsidiary of The West Penn Electric Co. ***Subsidiary of Ohio Edison Co.

BABCOCK & WILCOX
BOILER DIVISION

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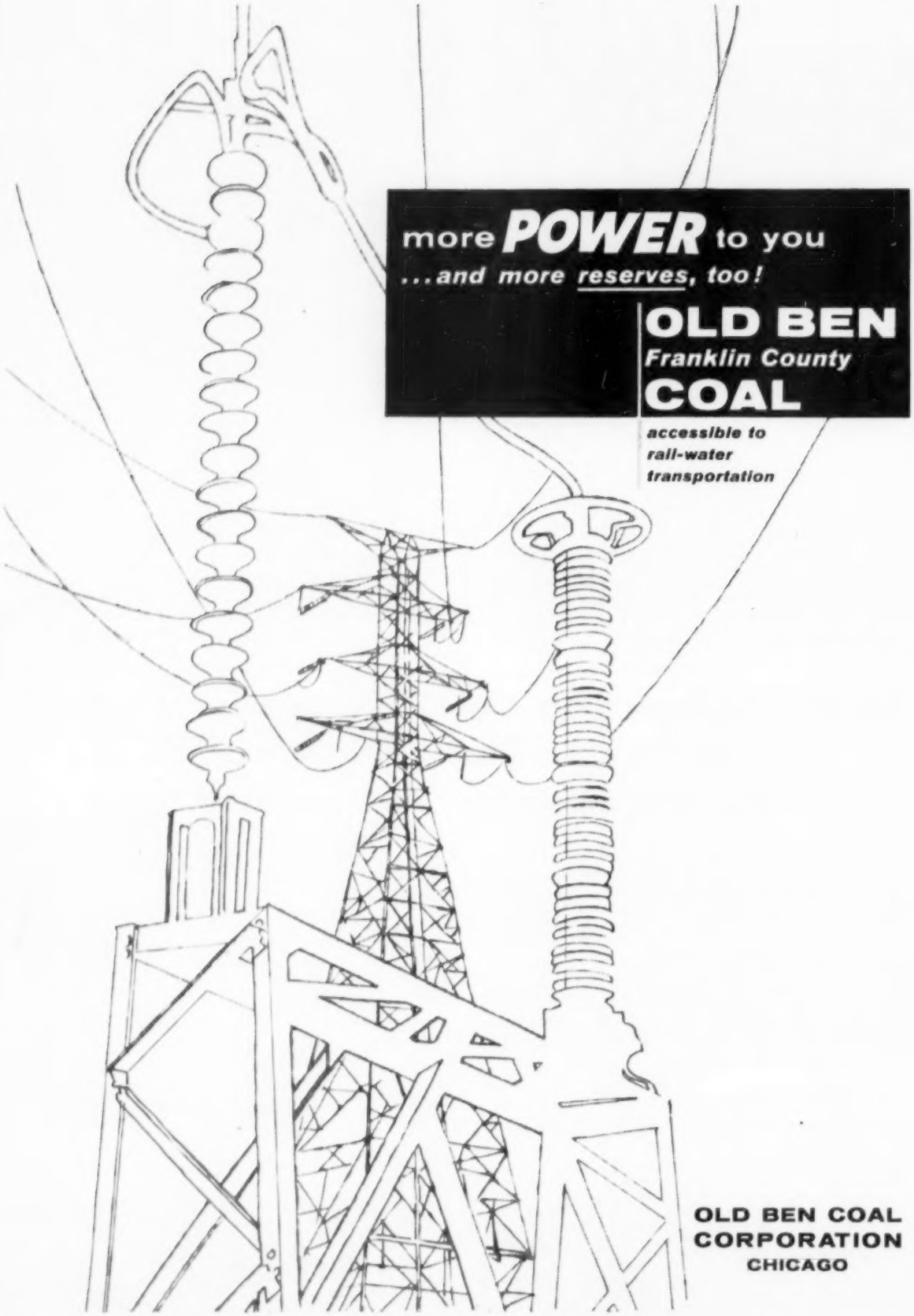

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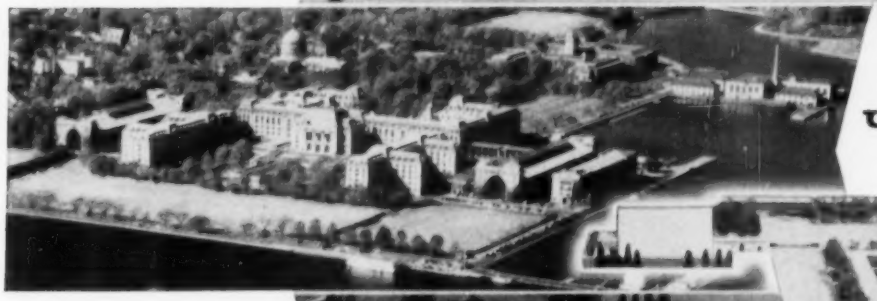
UNITED STATES MILITARY ACADEMY



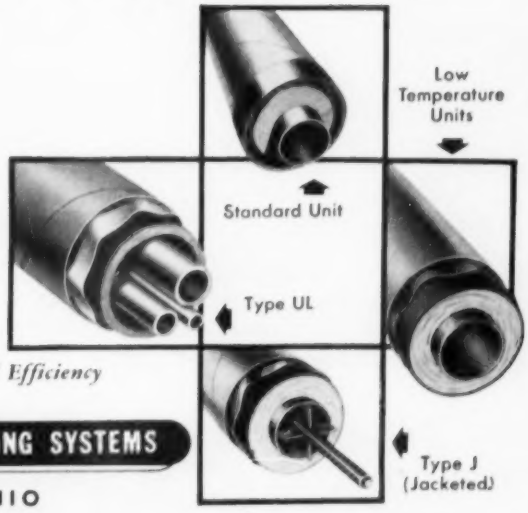
UNITED STATES NAVAL ACADEMY

UNITED STATES AIR FORCE ACADEMY

Photographs courtesy United States Military Academy, United States Naval Academy, and United States Air Force Academy.

Ric-wiL underground piping systems serve ALL three...West Point, Annapolis and NOW...the new Air Force Academy

West Point and Annapolis have been serviced by Ric-wiL piping systems as far back as 1931. Since 1946 alone over 15,000 feet of Ric-wiL prefabricated piping has been purchased for the nation's top military colleges. Installation of Ric-wiL piping at the new 17,500 acre United States Air Force Academy has already been installed. Ric-wiL is indeed proud of the part they have played in serving these military academies for a period of over twenty-five years.



Quality Piping Systems . . .
. . . of Exceptionally High Thermal Efficiency

SINCE 1910

RIC-WIL INCORPORATED — PREFABRICATED INSULATED PIPING SYSTEMS

BARBERTON, OHIO

IN CANADA: THE RIC-WIL COMPANY OF CANADA LIMITED

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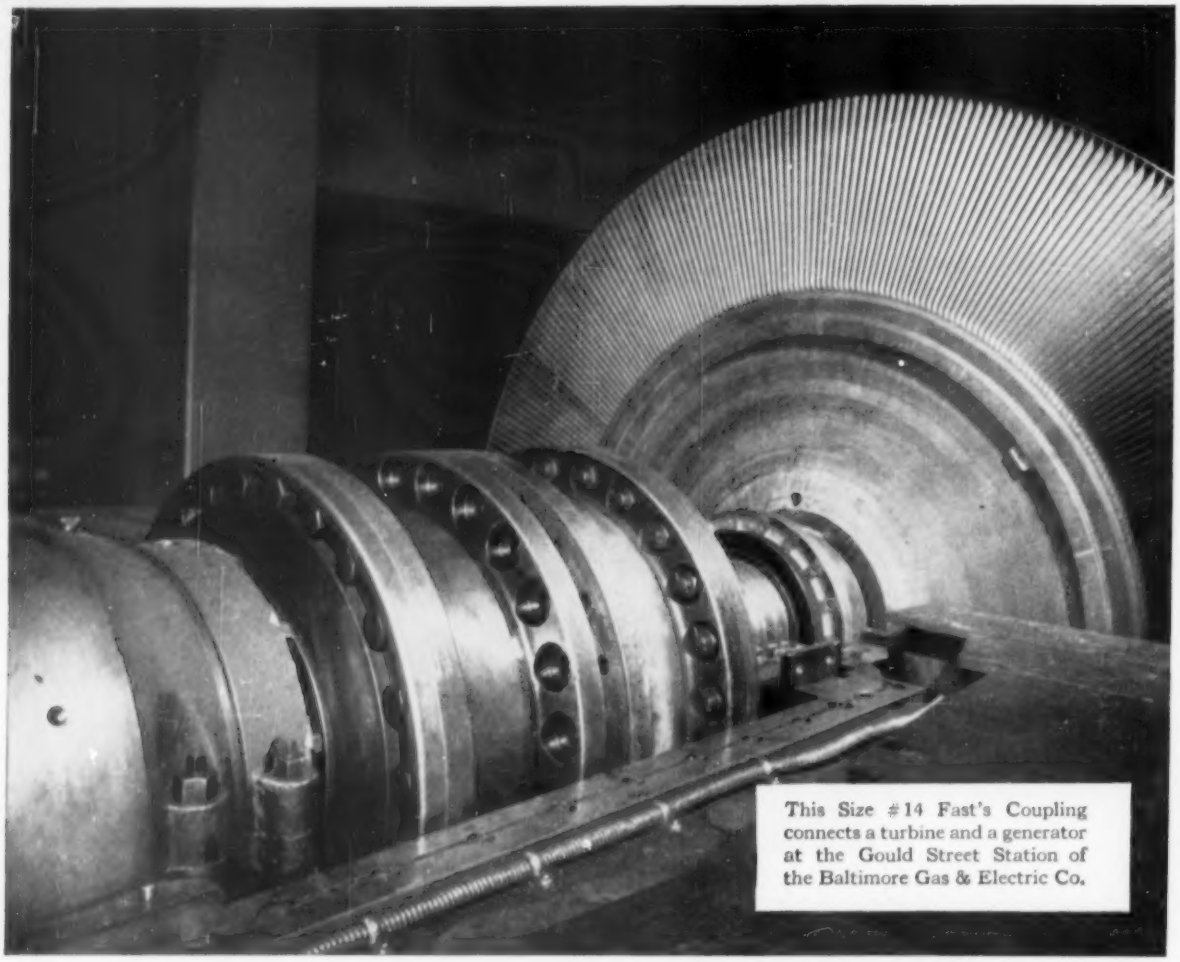

This Size #14 Fast's Coupling connects a turbine and a generator at the Gould Street Station of the Baltimore Gas & Electric Co.

This Fast's Coupling runs smooth after 29 years of service!

This Size #14 Fast's Coupling has never had a major part replaced since its installation on January 4, 1927.

The Baltimore Gas & Electric Company has provided excellent care and inspection . . . examining the coupling during each routine overhaul of the turbine and generator. The last inspection (shown above) was during the fall of 1955.

Unique design permits Fast's Couplings to compensate for both offset and angular misalignment of shafts and eliminates the wear of metal upon metal. It provides positive lubrication which forms a film on load-carrying surfaces of the teeth. Metal bearing rings located at the mid-axis of the teeth keep out dirt, grit and moisture—keep lubricant in. Fast's metal-to-metal seal protects the lubricant against pollution.

A Koppers engineer can show you how Fast's Couplings will give you extra years of service and reduce down-time. For more details, write to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.*, 3712 Scott Street, Baltimore 3, Maryland.

Koppers Company, Inc.
Metal Products Division
Baltimore 3, Maryland

Engineered **Products**
Sold With ***Service***

KOPPERS

THE ORIGINAL
FAST'S Couplings

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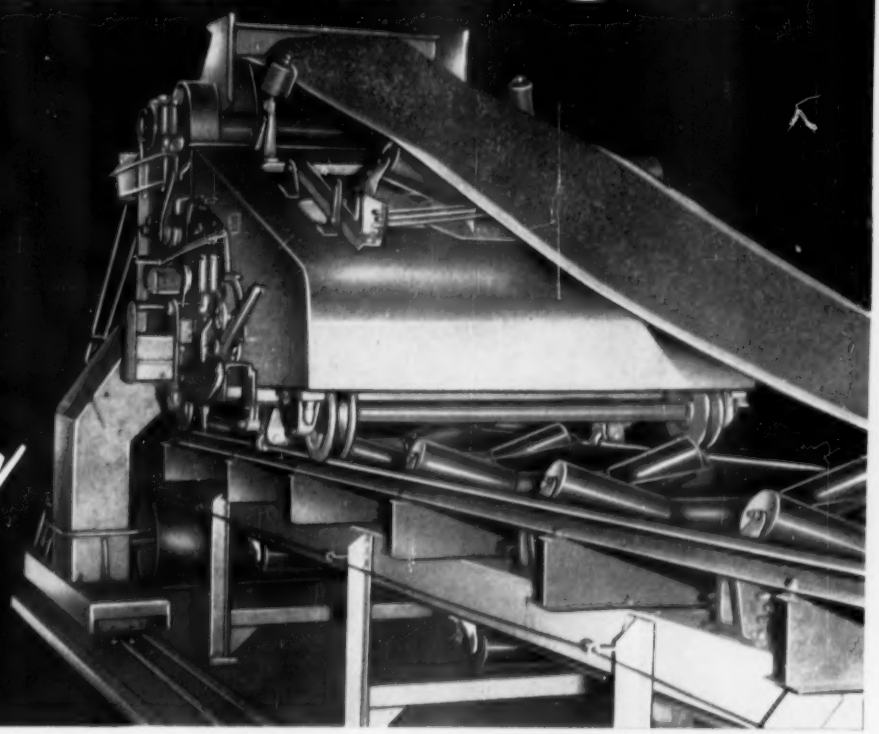
STEPHENS ADAMSON

coal conveying systems for *TODAY* and *TOMORROW*



S-A tripper and exclusive zipper bunker seal. Seal zips open and closed. Eliminates dusting.

The power plant built for present needs is expected to serve the next generation too. The men responsible for the purchase of vital coal conveyor systems for power generation may expect to buy only one such system in their lifetime.

Such a system must function flawlessly for years to come. It must be economical in installation and delivery costs and must be sparing of man power.

To create such a power servant demands the finest engineering, the best construction, and above all, experience. These are S-A qualities and they have been earned in long service to the power field. This is why, more and more in coal handling systems, the big name is S-A—the name with a 50 year reputation for building equipment that will serve the power needs of our generation—and the next.

Knittel crushers built by S-A and used to reduce run-of-mine coal to stoker size. They are compactly constructed, requiring little headroom and are extremely dependable. S-A crushers are available in many sizes and variations to meet specific requirements.

S-A REDLER conveyors and elevators, patented products, ideally move crushed coal over any plane, completely enclosed, eliminating all dusting problems. Specially designed flights move coal forward in a solid column. Discharge is possible at single or multiple stations.

S-A manufactures a wide range of material handling products in three complete plants in U. S. and Canada.

Belt Conveyors
Belt, Pan & Plate Feeders
Ship Loading Boom Conveyors
Stacking Conveyors
Storage & Reclaiming Systems
"Natural Frequency" Vibrating Conveyors
REDLER Conveyor-Elevators
ZIPPER Conveyor-Elevators
Conveyor Belt Cleaners
Headshaft Holdbacks
Grizzlies & Screens
Centrifugal Pilers
Bin Gates & Tunnel Gates
Car Pullers & Spotters
Bucket Elevators
Skip Hoists
SEALMASTER Ball Bearing Units

• *Write for a bulletin on any of the above products.*

SINCE 1901 S-A STEPHENS-ADAMSON MFG. CO.

STEPHENS-ADAMSON MFG. CO.

86 RIDGEWAY AVENUE, AURORA, ILLINOIS
LOS ANGELES, CALIFORNIA
BELLEVILLE, ONTARIO

For more data circle 528 on Post Card

FOR VOLTAGES UP TO 600...

There's a *Safe and Dependable* BUSS Fuse or FUSETRON Fuse to fit the needs of every user

If you want Plug Fuses . . .

Use BUSS Clear Window Plug Fuses

Their one-piece body and "safety" design guarantees protection.

They are most convenient to use too, because real big windows and white backgrounds permits entire fuse strip to be seen. Even in poor light a blown BUSS fuse is easy to find.

If you want to make safe protection REMAIN SAFE as well as REDUCE blowing fuses . . .

Use BUSS Fustats (have Type S base)

FUSTATS like Fusetron Fuses have a dual-element and therefore, stop needless blowing — and they do more.

They have a type S base that prevents anyone from replacing them with a penny or substitute — or using a size too large to protect.

FUSTATS fit standard plug fuse holders by means of an inexpensive adapter that locks in place and needs never to be replaced.

If you want to reduce blowing of Plug Fuses . . .

Use FUSETRON dual-element Plug Fuses

FUSETRON Plug fuses protect like ordinary fuses against short-circuits and overloads — but unlike ordinary fuses they won't blow on motor starting currents or other harmless overloads.

They are the type of fuses recommended in the 1953 National Electrical Code.

To protect motors and apparatus of voltages up to 125 against burnout . . .

Use 0 to 14 amperes BUSS Fustats

A FUSTAT of the proper size installed to handle only the motor current will reduce to a minimum the chance of a motor burnout from an excessive over-current. In like manner it will protect solenoids, coils and transformers against burnout.

FUSTATS have the same degree of Underwriters' approval for both motor-running and short-circuit protection as the most expensive devices made. They give all the protection it is possible to obtain with any device on the market.

FUSES! . . . THE SAFEST AND MOST DEPENDABLE PROTECTION YET DEVISED!

A fuse has just one vital part — a thin narrow strip of fuse metal. When the heat of a short-circuit is applied, the fuse link must melt and open the circuit.

The high speed operation of the fuse reduces to a minimum the danger of short-circuit damage to wiring and equipment.

Fuses offer dependable protection over the years.

The fuse link is sealed in. Dust can't get at it. Corrosion or oxidation can't increase its capacity or lengthen its blowing time.

There are no hinges, pivots or contacts to stick or get out of order.

Millions of fuses have been in operation 30 years or more, because there has been no trouble on the

Play Safe! Install BUSS Fuses or

If you want fuses that — abolish all needless blows, stop overheating in panels and switches, protect motors against burnouts . . .

Use FUSETRON dual-element Fuses

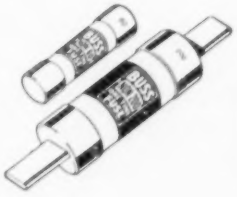
With rare exceptions, ordinary fuses or circuit breakers do not protect except against short-circuit but FUSETRON fuses provide TEN POINT protection.

1. Protect against short-circuits.
2. Protect against needless blows caused by harmless overloads.
3. Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation.
4. Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5. Protect motors against burnout from overloading.
6. Protect motors against burnout due to single phasing.
7. Give DOUBLE burnout protection to large motors — without extra cost.
8. Make protection of small motors simple and inexpensive.
9. Protect against waste of space and money — permit use of proper size switches and panels.
10. Protect coils, transformers and solenoids against burnout.

FUSETRON duel-element FUSES save you time and money because they are made to PROTECT — not to blow.

If you want Non-Renewable Fuses . . .

Use BUSS One-Time Fuses

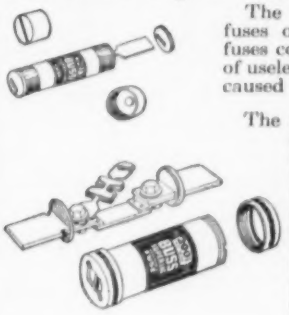


They save you time and trouble because they get the same engineering care in manufacture as do all products carrying the BUSS Trademark.

Every BUSS One-Time fuse can be depended upon to operate as intended under all service conditions.

If you want Renewable Fuses . . .

Use BUSS Super-Lag Renewable Fuses



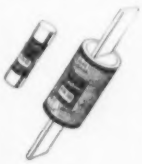
The big advantage of these fuses over all other renewable fuses comes from the prevention of useless interruptions of service caused by needless blows.

The reason for this performance is found in the design of the fuse-case which assures good contact on the fuse link, even if the fuse is renewed by an inexperienced person — and by the time-lag built into the link that prevents the fuse from opening on motor starting currents or other harmless overloads.

If you want SAFE protection on loads above 600 and up to 5000 amps . . .

Use BUSS Hi-Cap Fuses

On voltages up to 600, high speed operation on heavy shorts limits current to safe values. This minimizes damage to equipment and cuts down dangerous stresses on transformers.



For Short-Circuit Protection or when fast opening is desired . . .

Use BUSS Limitron Fuses

The extremely fast opening characteristics of these fuses prevent heavy short-circuit currents from building up under fault conditions.

For protection of TV, Radio, Instruments, Radar, Avionics and Electronic Equipment . . .

Use BUSS and FUSETRON Small Dimension Fuses

A complete line is available. Made in Dual-element (slow-blowing), Renewable and One-Time types in sizes from 1/500 ampere up.

And there is a companion line of BUSS Fuse Clips, Fuse Blocks and Fuse Holders to take them.

circuits they are protecting and therefore no occasion to open.

Yet, after years of inactivity, you can be sure the fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

NO RECALIBRATION COSTS

When Fusetron fuses do blow, there is no recalibration needed. As quickly as the fault in the circuit is corrected, you slip in a new fuse that has been CALIBRATED AT THE FACTORY BY ENGINEERS — a fuse that is as safe and dependable as the one that blew.

FOR MORE INFORMATION ON BUSS AND FUSETRON FUSES WRITE TO BUSSMANN MFG. DIVISION McGRAW-EDISON CO. ST. LOUIS 7, MO.

FUSETRON

TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION

BUSS

1157

Fusetron Fuses Now! ***THROUGHOUT THE ENTIRE ELECTRICAL SYSTEM***

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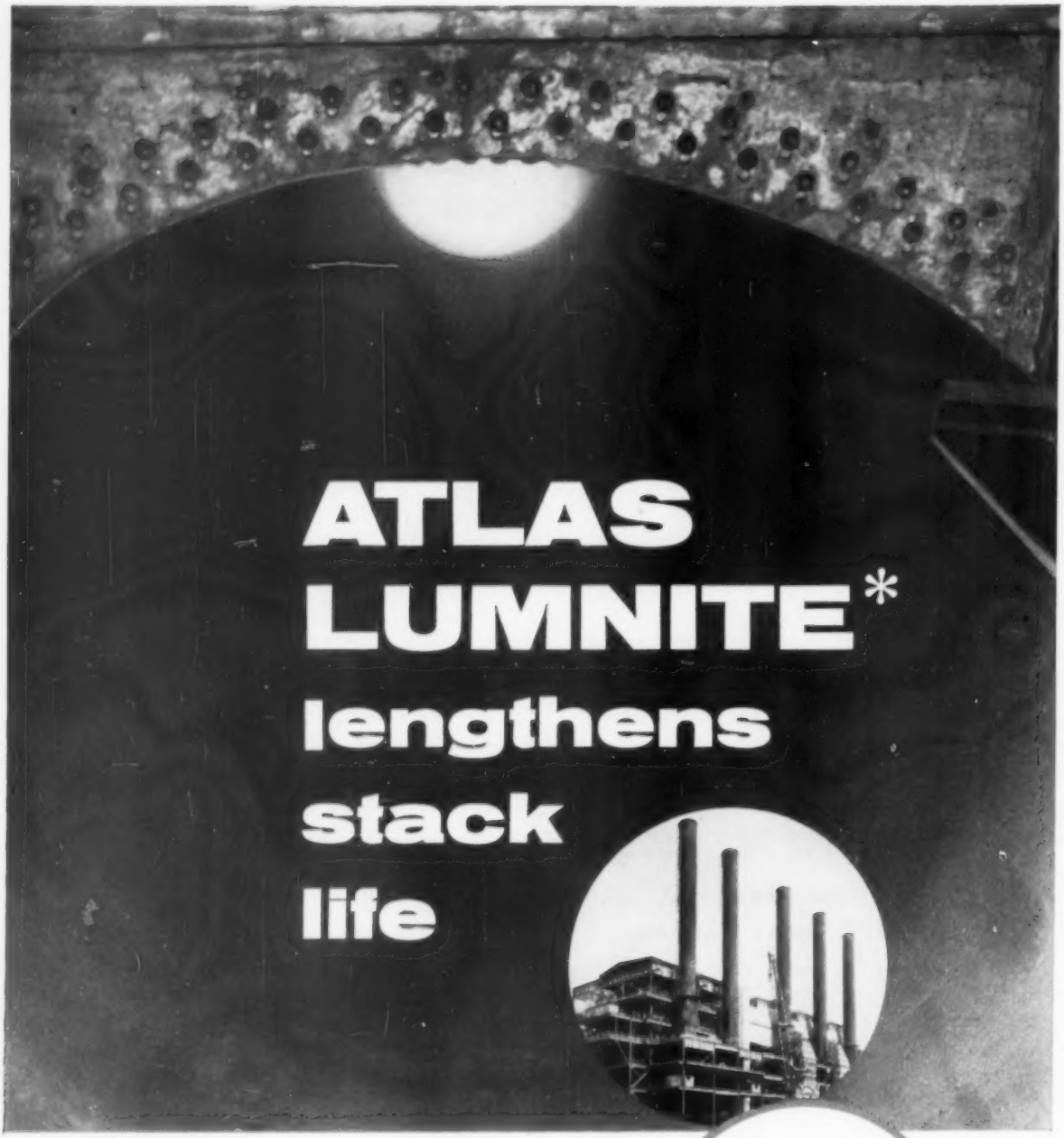

GUNITED STACKS AND BREECHINGS at Linden, N. J., generating station of Public Service Electric and Gas Co. (Newark) are among the growing number of power-plant installations using concrete linings made with Lumnite cement. From ash hoppers to stacks, Lumnite linings reduce maintenance costs and provide long service life.

- Lumnite-made industrial concretes give rugged resistance to heat, corrosion, abrasion and thermal shock.
- Placement is fast and easy—by guniting, pouring or plastering.
- Downtime is reduced to a minimum—service strength is reached within 24 hours.

For maximum convenience, use Lumnite-made castables. These are packaged mixtures, ready for use. Just add water, mix and place. Made and distributed by leading manufacturers of refractories.

For more information, write: Universal Atlas, 100 Park Avenue, New York 17, N. Y.

UNIVERSAL ATLAS CEMENTS

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* **"LUMNITE"** *is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

L-154

UNIVERSAL ATLAS CEMENT COMPANY—member of the industrial family that serves the nation—**UNITED STATES STEEL**

OFFICES: *Albany • Birmingham • Boston • Chicago • Dayton • Kansas City • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • St. Louis • Waco*

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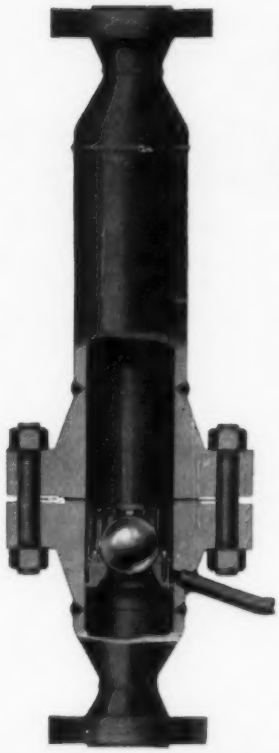


Variable-orifice desuperheater for precise temperature control

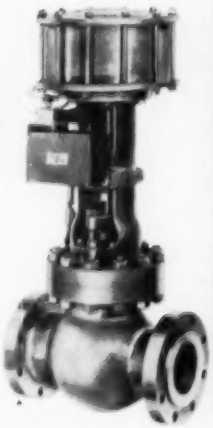
Using a weighted steel ball for controlling the orifice opening, the new Copes-Vulcan Variable-Orifice Desuperheater assures close control of reduced steam temperatures regardless of load variations. Mixing and vaporization of cooling water and steam are so complete that reduced steam temperature can be held constant only 20 feet downstream from the desuperheater outlet — even over a 50-to-1 load range.

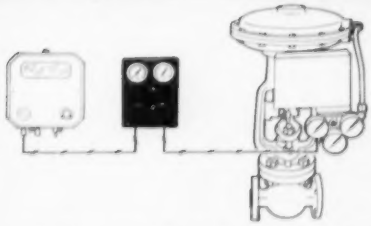
Unique design eliminates the need for excess piping, atomizing steam, spray nozzle or glands. No excess water needs to be removed from the stream.

The Variable-Orifice Desuperheater is one of a complete line — each type engineered to meet particular operating conditions. Copes-Vulcan designs each station to meet individual requirements. Write for details.

Two basic valves built to handle more jobs

With the new diaphragm-actuated Type CV-D and piston-actuated Type CV-P valves, Copes-Vulcan offers new simplicity in design, wider flexibility in application for remote control service. Type CV-D is reverse or direct acting in sizes up to 14-inch at unlimited pressures. Type CV-P is ideal for highest valve-operating force, and precise positioning. Write for Bulletin 1027.





Pneumatic control stations simplify performance . . . maintenance

This Remote-Set AMS-4 Station is used with pneumatic stacked-diaphragm controllers . . . provides adjustable set-point loading or independent manual operation. Copes-Vulcan builds auto-manual stations in Standard, Remote-Set and Cascade types, and Manual Loading and Miniature Stations. Write for Bulletin 1031.

Patent applied for

COPES VULCAN

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

BLAW-KNOX

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CONSTRUCTION NEWS

Birmingham, Ala. — Alabama Power Co, Alabama Power Company Building, has announced the grant of a 50-year license from the FPC for a proposed hydroelectric project on the Black Warrior River in Alabama. Company plans to construct a high earth and rock fill dam at the proposed Lewis Smith Dam Development, located at the upper New Hope Dam site on the Sipsey Fork of the Black Warrior River. Dam will create a reservoir with a usable power storage of 400,000-acre-feet. Proposed power plant reported to cost an estimated $37,000,000, will have an initial capacity of 80,000 kw, with provision for the installation of a similar unit at a later date.

Riverside, Calif. — California Electric Power Co, 3771 W Eighth St, has arranged financing to provide a fund of about $7,000,000, through sale of preferred stock issue, proceeds of which will be used to pay off short term construction loans and for expansion and improvements in power plants and system, including increased generating capacity, power substations, transmission lines and other operating facilities.

Colorado Springs, Colo. — City of Colorado Springs, City Council, City Hall, has arranged financing through the sale of bond issue in the amount of $5,500,000, proceeds to be used in part for expansion and improvement in municipal power plant, including new generating facilities, power substations, transmission lines and other miscellaneous work.

Hartford, Conn. — Directors of Hartford Electric Light Co, 266 Pearl St, and Connecticut Power Co, 36 Pearl St, have announced plans for the merger of the two utilities pending approval of recommendations submitted to stockholders of both companies and State and Federal Power authorities. Terms of the consolidation call for the exchange of three-fourths share of Hartford common for each share of Connecticut Power outstanding. Preferred stock will be exchanged on a share for share basis. Two utilities serve about 212,000 electric and gas customers and have a combined investment of $175,000,000.

Chicago, Ill. — Commonwealth Edison Co, 72 W Adams St, has arranged financing through stock issue, totaling $25,000,000, proceeds of which will be used to meet costs of the utility's construction program. Plans for company expansion and system improvement from 1957 through 1960 calls for an expenditure of $650,000,000, of which total $280,000,000 will be raised through issuance of additional securities. Program calls for increased generating capacity, power substations, transmission lines and miscellaneous work. Company has filed a registration statement with the SEC covering proposed stock issue.

Chicago, Ill. — Commonwealth Edison Co, 72 W Adams St, has authorized plans for the construction of new generating facility at company's Crawford Station. New unit to be installed will have an initial capacity of 305,000 kw. Work will get under way soon for scheduled operation in 1961. By the summer of that year, new generating unit will boost company's net generating capability to 5,608,000 kw or nearly two and a half times the level in 1945. Present generating capacity of the company is 4,116,000 kw. Cost of project representing a multi-million dollar installation will be included in the company's four year expansion program budgeted at $650,000,000 through 1960.

Peking, Ill. — Central Illinois Light Co, 316 S Jefferson Ave, Peoria, Ill., has authorized plans for the construction of a large steam-electric power plant on the west side of the Illinois River, just north of here. Preliminary clearing work on the plant site is already under way for the plant which is scheduled to go into operation by mid-1960. Plant and necessary equipment to cost approximately $26,000,000.

Worcester, Mass. — Norton Co, 50 New Bond St, manufacturers of grinding wheels, abrasives, refractories, etc, has announced plans for the installation of additional steam generating equipment which will increase by better than 75 per cent the capacity of company's main power plant here. Installation of new units will represent the final stages of company's present major multi-million dollar expansion program. Power expansion plans call for the installation of new large boilers and auxiliary equipment, power house addition, and new coal handling equipment. Cost of total installation of increased power units reported to be $1,000,000.

New York, N. Y. — Consolidated Edison Co, Inc, 4 Irving Place, has made an offer to the City of New York for the outright purchase of three subway transit power plants, located at 59th St and the Hudson River, at 74th St and Franklin Roosevelt Drive, and Kent Ave, Brooklyn, N. Y., for the sum of $90,000,000. Payment for the three plants would be spread over a period of ten years and power to operate the city's transit system would be sold to the city by Consolidated Edison Co. The sale at present is opposed by the Transit Authority of the City of New York but favored by five civic and business groups who are bringing pressure to bear for the sale.

Niagara Falls, N. Y. — Federal Power Commission has granted the Power Authority of the State of New York conditional authority for the construction of a mammoth power project here, estimated to cost upon completion, approximately $600,000,000. Commission, in granting a 50-year license, reserved for future decision the type of water conduits to be installed and the extent and area of the reservoir. Construction of any of the project structures is subject to the approval of the commission. Project will have an installed capacity of about 2,190,000 kw when completed at a projected time in late 1961. Power Authority is required to give preference and priority for power to public bodies and rural cooperatives, within economic transmission distance in disposing of 50 per cent of the project power.

Charlotte, N. C. — Duke Power Co, 422 S Church St, has arranged for sale of bond issue in the amount of $50,000,000, a considerable portion of which will be used for extensions and improvements in company's power plants and system, including increased generating capacity, transmission lines, power substations and other installations for increased electrical output.

Dayton, Ohio — Dayton Power & Light Co, 25 N Main St, has announced plans for financing an amount of $25,000,000 through the sale of bond issue, proceeds of which will be used in part to pay off existing bank loans and to defray part of the cost of the 1957–1958 construction program, including increased generating facilities, power substations, transmission lines and miscellaneous work.

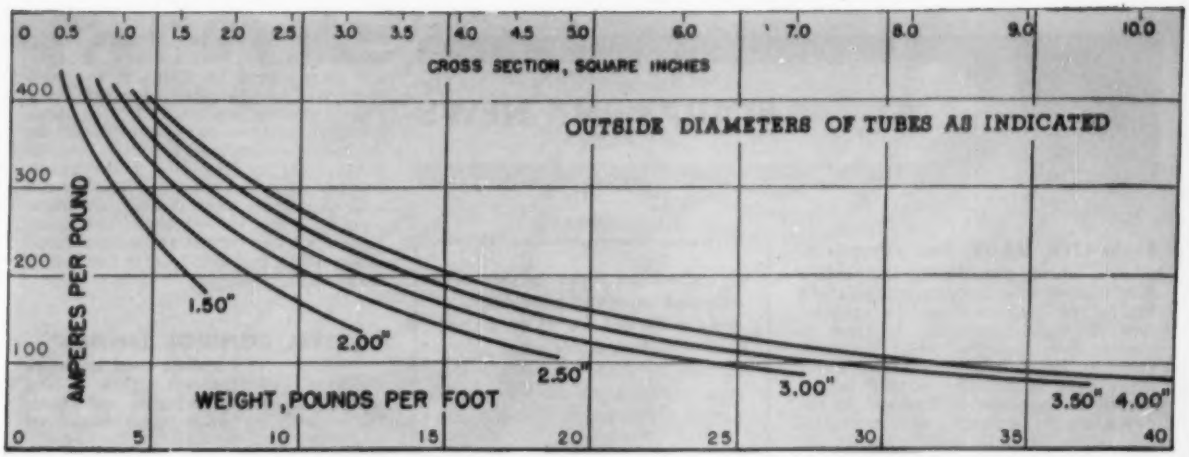
Rayland, Ohio — Cleveland Electric Illuminating Co, Cleveland, Ohio, has authorized plans for the construction of a major electric power plant here, approximately 110 miles southeast of Cleveland. Company plans to move electric power to Cleveland area by a 345,000-volt transmission line, one of the largest capacity power line installations in the country. First steam-electric generating unit with an initial capacity of 335,000 kw will be placed in operation in 1961. Construction date was set for early 1958. Plant and connecting transmission system reported to represent an investment of better than $75,000,000, is part of a $262,000,000 construction program scheduled through 1961.

Jamestown, R. I. — Commerce Oil Refining Co, 515 Madison Ave, New York, N. Y., has announced that they have awarded a contract in the amount of $50,000,000 to the Fluor Corp, Ltd, to design and construct a large 43,000-barrel per day refinery, including large boiler plant and auxiliary equipment, salt water cooling system, tank farm and docks. Facility will be erected on a 600-acre site on the northern end of Cananicut Island, in Narragansett Bay, near Providence, R. I., and will be designed primarily for the production of high-octane gasoline.

Catawba, S. C. — Bowater Carolina Corp, subsidiary of the Bowater Corp of North America, has announced plans for the construction of a large $38,000,000 pulp plant here for the manufacture of semi-bleached wood pulp from native pine. Company plans large steam power house on large tract of land recently acquired. Project will comprise a large group of buildings and is scheduled for operation in the summer of 1959. Work will get under way soon under supervision of Daniel Construction Co. When completed, wood pulp from the mill will be shipped to other company facilities for processing.

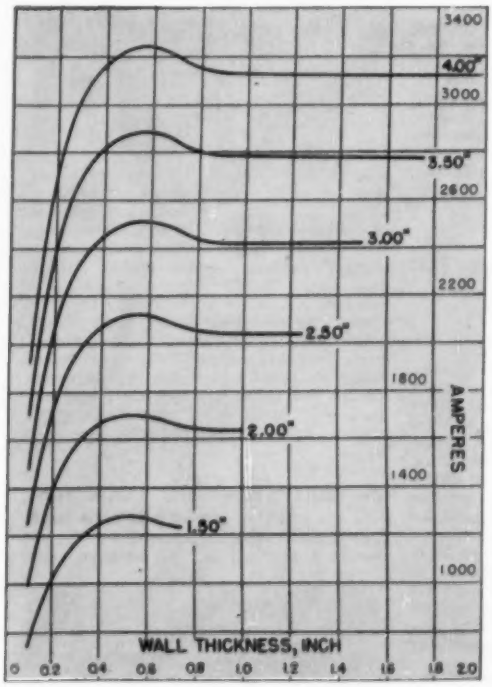
Knoxville, Tenn. — Tennessee Valley Authority has announced plans for the construction of an $86,000,000 steam-electric generating unit with an initial capacity of 500,000 kw. Installation is tentatively scheduled as a major addition to the TVA Widows Creek plant, approximately five miles southwest of Bridgeport, Ala., and some forty-five miles southwest of Chattanooga, Tenn. Initial contracts for the boilers and turbine generators totaling $27,000,000, have been issued. Construction will get under way at once for scheduled completion in 1960.

Milwaukee, Wis. — Wisconsin Public Service Corp, 1029 N Marshall St, has arranged financing through the sale of stock issue, proceeds of which will be used in part for company's construction program to cover increased generating equipment, transmission lines and other operating facilities. Company plans to realize about $5,000,000 through sale of stock issue.



60-CYCLE CURRENT ratings of six round copper tubes in terms of weight per foot.

How to carry more amperes per pound of copper



THE INFLUENCE of wall thickness on the 60-cycle current rating of six round copper tubes.

THIN-WALL TUBES with low wall-thickness-to-diameter ratio offer decided electrical advantages—and opportunities for cutting bus costs—wherever mechanical requirements permit. The charts above and at the left show the 60-cycle skin-effect phenomenon characteristic of six representative sizes of round copper tube, 1.5" to 4.0" O.D. The curves cover the entire range of wall thickness from solid round rods, at the right, to the thin-walled tubes in common use at the left. What is true of round tubes is also true of other tubular bus shapes.

INSTALLATION ECONOMIES. When round tubular bus conductors can be selected in thin-wall sizes from the standard pipe dimension schedules, it is possible to effect further economies by the use of stock sizes of supports, connectors, tap clamps, and other necessary hardware available in great variety in dealers' stocks.

More complete information on tubular conductors is available in the Sixth Edition of The American Brass Company's Publication C-25. This 62-page booklet has a wealth of general information on the properties of copper conductors—plus convenient data for the most commonly used sizes of all types of rigid bus conductors.

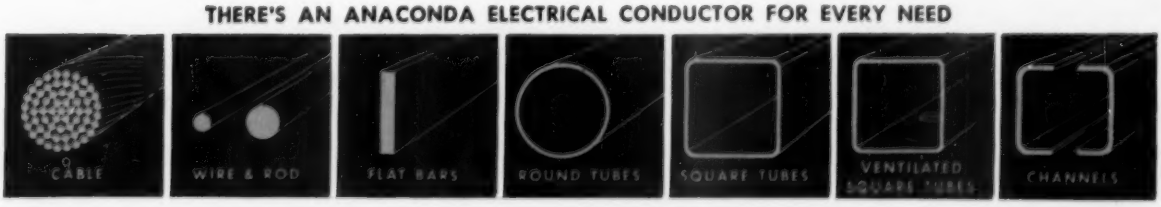
TECHNICAL SERVICES. Anaconda specialists are available to help you in the solution of technical problems involving the use of Anaconda Bus Conductors. For such service, or for a copy of Publication C-25, see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. B7100

ANACONDA®

COPPER CONDUCTORS

Made by The American Brass Company

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED



For more data circle 532 on Post Card

EQUIPMENT NEWS

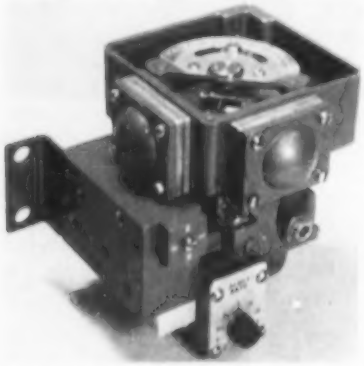
Described on these pages are new and improved products. Use Reader Service Cards on pages 123-124 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

1—WATER GAGE has temperature equalizing assembly

Now incorporated in this manufacturer's Multi-Port Bi-Color Gage is a temperature equalizing assembly designed to overcome an inherent error in water gages — that of indicating the water lower than it actually is, due to the cooling of the water in the gage. In the new assembly, a steam jacket surrounds the ports, keeping the water in the gage at or near the temperature and density of the water in the drum. This, it is claimed, eliminates all or nearly all of their error. Circulation in the jacket is made independent of circulation in the gage itself. The lower connection of the jacket is to the boiler downtake, at least 12 ft below water level. The assembly is reported most effective on boilers operating above 1500 psi. Diamond Power Specialty Corp.

2—PNEUMATIC CONTROLLER offers easy band adjustment

Type VC Pneumatic Controller features a simple, easy proportional band adjustment from 2 to 500 percent and less than 0.05 percent dead band as well as either remote pneumatic or local spring set point adjustment. Design of this controller is based on company's null-balance-vector principle for accuracy, sensitivity, compactness and interchangeability of parts. Simply loosening



a lock screw and moving it along a scale changes the proportional band of this controller. A needle valve permits repeating a reset rate without trial and error. Reset rate is from 0.1 to 50 repeats per minute, and controller action may be reversed without changing parts.

The controllers can be furnished for panel or post mounting, and with a weatherproof cover. Standard pressure ranges for feedback, pneumatic set point and output are 3 to 15 psi. Air supply required is 0.2 scfm at 18 to 20 psi. Manufacturer notes that spare parts problems are minimized and training problems simplified if this controller is used with other instruments in the same line because a common pneumatic component is used. Folio 57-2 gives data. Republic Flow Meters Co.

3—SHUT-OFF VALVE features positive seating

Figure 202 is a quick-acting shut-off valve for air, water, gas or oil service. Features announced include positive seating by spring and line pressure; a replaceable resilient disc for positive seal; full opening or closing by 90 deg movement of handle; cam to hold handle in open position; also vertical or horizontal position of the handle indicates whether valve is open or closed. It is made in $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$ in. sizes, for use on pressures to 150 lb at temperatures to 250 F. Bulletin 39-8 gives details on this valve. Homestead Valve Mfg. Co.

4—VALVE STEM PACKING for medium temperature service

Style 5022 is a molded type valve stem packing ring made from copper wire inserted asbestos yarns braided and impregnated with Teflon suspensoid and die formed into rings. Heart of the packing is the Teflon which gives it its characteristics and versatility. Offering mechanical strength and toughness, packing is described as dense and firm, resistant to seepage and able to withstand physical abuse. The Teflon acts as lubricant. According to company, packing is serviceable at temperatures to 500 F, and exhibits low flow under high pressure; it shows a high degree of chemical inertness, and is unaffected by known chemical agents, except molten alkali metals. It will not debase or discolor product handled, manufacturer states. The Garlock Packing Co.

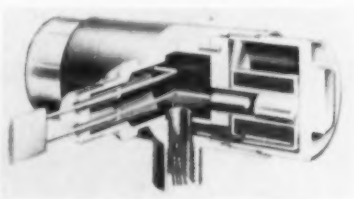
5—COAL SCALE ALARM warns of fuel shortage

The Coal Alarm is designed to provide automatic protection against coal supply failure in pulverized or stoker-fired operations. This system is tied in with the stoker or pulverizer feeder shaft, and sounds a warning when coal supply runs low or arches. Heart of the system is a magnetic switch which receives impulses from a magnet mounted on the pulverizer or stoker shaft. This transmits electrical impulses to an electric stop counter which registers each revolution of the feeder, it is explained. The setting for alarm purposes is based on the feeding capacity per revolution of the feeder.

Normally, a full supply of coal is maintained ahead of the boiler, and a definite number of shaft revolutions of stoker will feed a ton of coal. For a 500-lb scale therefore, a four discharges will be required to maintain the coal supply. The electric counter, with pointer setting, is thus set for the number of revolutions to deliver 500 lb. As the scale discharges its load, the counter resets itself to zero. But if the preset number is reached or exceeded before the scale discharges another load, an alarm is sounded and the operator has time to investigate and correct any unusual condition before losing the fire in the boiler. Richardson Scale Co.

6—LEVEL CONTROL for liquids, solids and slurries

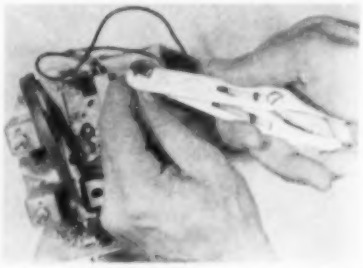
Model CL-10 Dynatrol utilizes a new design principle for accurate and versatile high or low point detection or narrow range proportional control of liquid, solid and slurry levels. This small and rugged control has a positive acting electrical output control signal that varies with amount of immersion of the 120 cps



vibrating paddle in the medium being detected. The output signal can be used to control the operation of any type of electrical equipment. Design allows sensitive transmission of vibrational energy from driver end to the sensing paddle and back to the output signal end through a linkage path welded to rigid metal pressure seals at the node points where zero amplitude of vibration occurs. Unit is rated for 3000 psig pressure, explosion-proof 115 v a-c, corrosion resistant and takes any mounting position with only $\frac{3}{4}$ in. NPT pipe opening required. Automation Products, Inc.

7—WIRE STRIPPING TOOL features positive lock

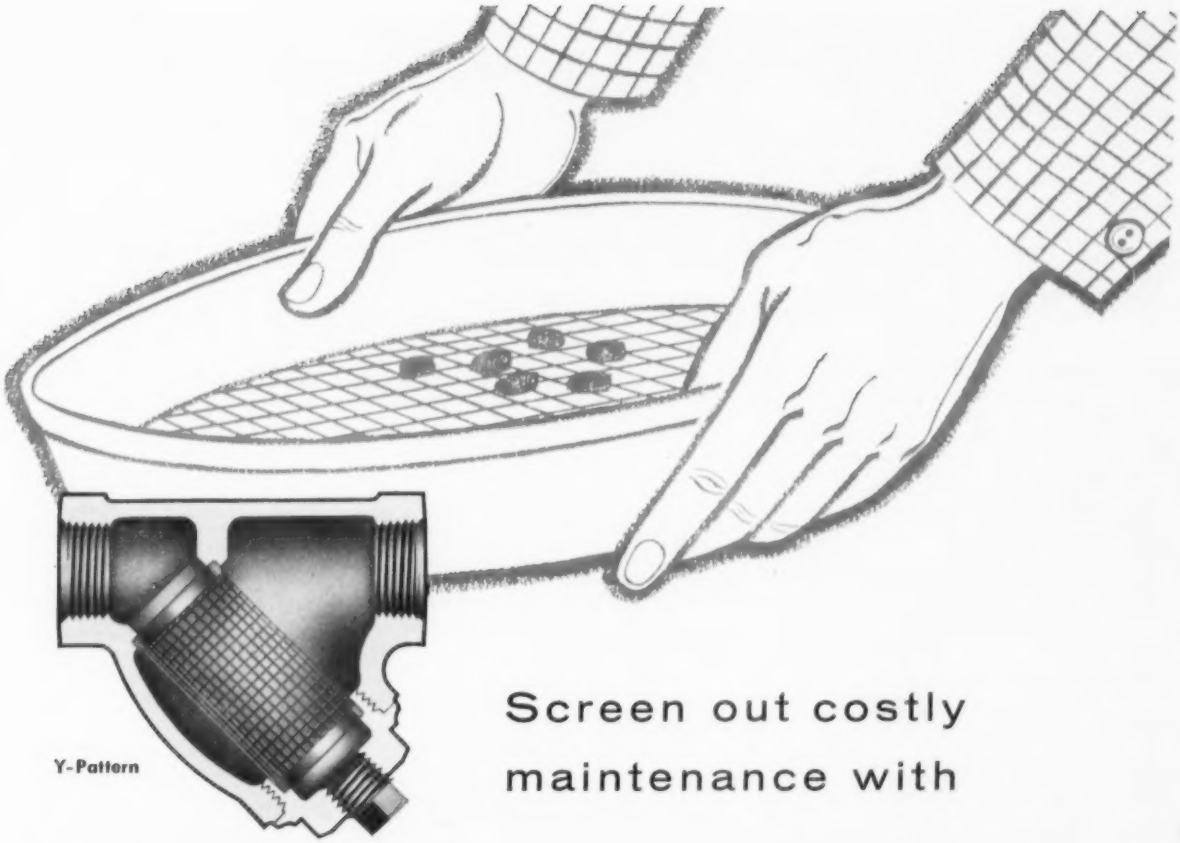
The Strip-It features a positive lock that can be easily adjusted to strip any size



No. 10 through 20 single or standard wire. Made of steel, the Strip-It will snip wire as well as strip it. Hunter Tool Co.

8—MECHANICAL DRAFT FAN gives high efficiencies

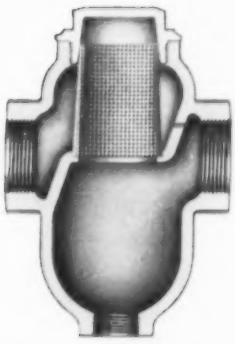
Engineered around an airfoil backward curved non-overloading type centrifugal wheel, these Airfoil mechanical draft fans are reported to give mechanical efficiencies up to 95 per cent. The fan's



Y-Pattern

Screen out costly maintenance with

CRANE SEDIMENT SEPARATORS



Vertical Types

Crane Sediment Separators positively and automatically trap foreign matter in fluid handling lines—steam, water, air, oil or gas, high or low pressure—and hold it for easy removal.

Dirt, scale, sand and other injurious particles are prevented from damaging or spoiling product and ruining valve seats, automatic devices and other delicate equipment.

Because of their exceptionally large screening areas—more than 500% greater than pipe area—Crane Sediment Separators assure unrestricted flow of product, even when partially plugged. Note special blow-off connection for drain valve attachment which permits easy cleanout without interrupting flow service.

LITERATURE SENT ON REQUEST

Available in both Y-patterns and vertical types, with full range of capacities and sizes. For literature on Crane Sediment Separators, see your Crane Representative or write to address below.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

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hollow section airfoil blades are designed on same principle as an airplane wing. Smooth passage of air over the blade surface eliminates eddy currents, lowering noise level 20 to 40 per cent and requiring less horsepower, according to company. The fan furnishes static pressure from ¼ to 32 in. in volumes ranging to 1,097,940 cfm and temperatures up to 900 F. Inlet vane controls provide for manual or automatic regulation of fan output. The vane control is constructed as an integral part of the inlet cone. Since it depends on a cam action design, there is said to be no blade flutter. Housings are continuous-weld heavy plate steel. Chicago Blower Corp.

9—CLEANING SOLVENT for oily, machine parts, equipment

This pleasantly scented safety cleaning solvent is introduced for wipe or dip cleaning of greasy and oily machine parts and electrical equipment. According to manufacturer, the cleaner replaces carbon tetrachloride and other chlorinated solvents and has no flash point under normal usage. It is reported to compare in toxicity to Stoddard Solvent and offer the advantage of high solvent power with extremely rapid evaporation. Harco Chemical Co.

10—GAS FLOW CONTROL for low capacity space heaters

Manually-operated for space heaters, the TSC-110 is a gas flow control incorporating an automatic pilot safety device which shuts off flow of gas to both main burner and pilot light in case of pilot outage. The control knob has a metal stop which prevents accidental shut off of pilot during normal operation. Designed for low capacity gas-fired space heaters, the control is available with or without a built-in dust and gum filter. Manifold piping is standardized to reduce inventory. Grayson Controls Div., Robertshaw-Fulton Controls Co.

11—HAND VIBROGRAPH makes permanent vibration records

The Davey Hand Vibrograph is a compact self-contained instrument for making permanent records of machinery vibration on a continuous paper chart.

It measures amplitude and frequency. According to company, wave forms are shown in the minutest detail. A salient feature is an instantaneous external adjustment which selects degree of magnification desired, giving 40, 20, 10 or 5:1 ratios. No battery or outside power source is required. A carbon shod ball bearing probe is provided for taking measurements directly on the surface of rotating shafts. The Vibroscope Co.

12—PLUG-IN BUSWAY permits outlets over a wide area

Type DH is announced as a 100-amp plug-in busway designed for use where plug-in outlets over a wide area are necessary. It can be hung on 10-ft centers in the edgewise position. Type DH is used as a plug-in system and as a feeder for lighting systems and as a feeder or branch circuit from a switchboard or other power-consuming device. When a 100-amp or less receptacle is required to feed a portable welder or similar machine, Type DH can be installed vertically between flanges of a steel column or against a wall. The overlap pressure joint of Type DH is joined mechanically and electrically by tightening six captive screws. Busway is rated 100-amp, 600 v maximum, three- and four-wire construction and is reported able to withstand a short-circuit current of 15,000 amp RMS asymmetrical (12,000 amp RMS symmetrical) when properly protected by a main circuit breaker, or a short-circuit current of 100,000 amp asymmetrical when protected with a 100- or 150-amp Type CLF current-limiting fuse. General Electric Co.

13—PACKAGED BOILER designed for processing plants

The Monitor is a compact packaged boiler (the 40-hp size is only 53 in. high) designed to bring large boiler industrial quality to small and medium sized processing plants. It is fully automatic in operation, and needs no chimney; a simple vent removes any combustion gases from the boiler room. The Monitor is available through 60 hp or 2070 lb of steam per hour and can be fired with oil or gas or furnished with a combination burner. Manufacturer points out that it is factory assembled and complete, including insulation and metal jacketing. Cleaver-Brooks Co.

14—LEVEL INDICATOR measures with ultrasonics

The ultrasonic pulse-ranging principle of liquid level measurement utilized in the Model 300 Echogage is designed to eliminate need for floats, linkages, synchros, or any moving parts. The gage is designed to indicate liquid levels in storage tanks and dewar vessels for corrosive chemicals, liquefied petroleum gases, liquid carbon dioxide, oxygen, and all cryogenic liquids, and is also suggested for applications requiring precise location of demarcation line existing between immiscible liquids.

Liquid level is read directly in feet on a large meter provided with two ranges to accommodate tanks up to 15 ft high. A built-in calibration feature serves to assure correct level readings despite changes in velocity of sound propagation caused by varying temperatures, specific gravities, and similar differences between liquids being gaged. One common indicator will gage as many as six transducer-equipped tanks, company says, within a radius of 1500 ft. Additional tanks can be accommodated by using auxiliary switch. Indicator is transistorized, and consumes only 5 w of 120 v, 60 cycle power. Bogue Electric Mfg. Co.

15—DIELECTRIC COOLANT HOSE withstands high temperatures

Fluoroflex-T R536 Hose contains no metal, it is pointed out, and it combines excellent high voltage insulation, protection against corona and moisture absorption, unusual flex-life and vibration resistance. This hose is expected to answer flexible hose requirements for collant lines on large electric generators and to be of value in the production of high power transformers and similar equipment. Its suitability for these applications is enhanced by the chemical inertness of the Fluoroflex-T tube compound which, according to manufacturer, tends to make it resistant to deterioration. Resistoflex Corp.

16—ALUMINUM METER for the low-pressure services

The Model 750 is a lightweight, single-joint aluminum gas meter designed primarily for services requiring large capacity at low working pressure. The meter

weighs only 47 lb — about half the weight of many meters of its capacity — and can be carried and installed by one man. Its 15-psi working pressure and capacity of 750 cu ft per hour at ½ in. differential and 1600 cu ft per hour at 2 in. differential suggest its use for commercial and small industrial installations. The meter is available with either 45 light steel spud connection or 1½-in. pipe tap connection. Meter and Valve Div., Rockwell Mfg. Co.

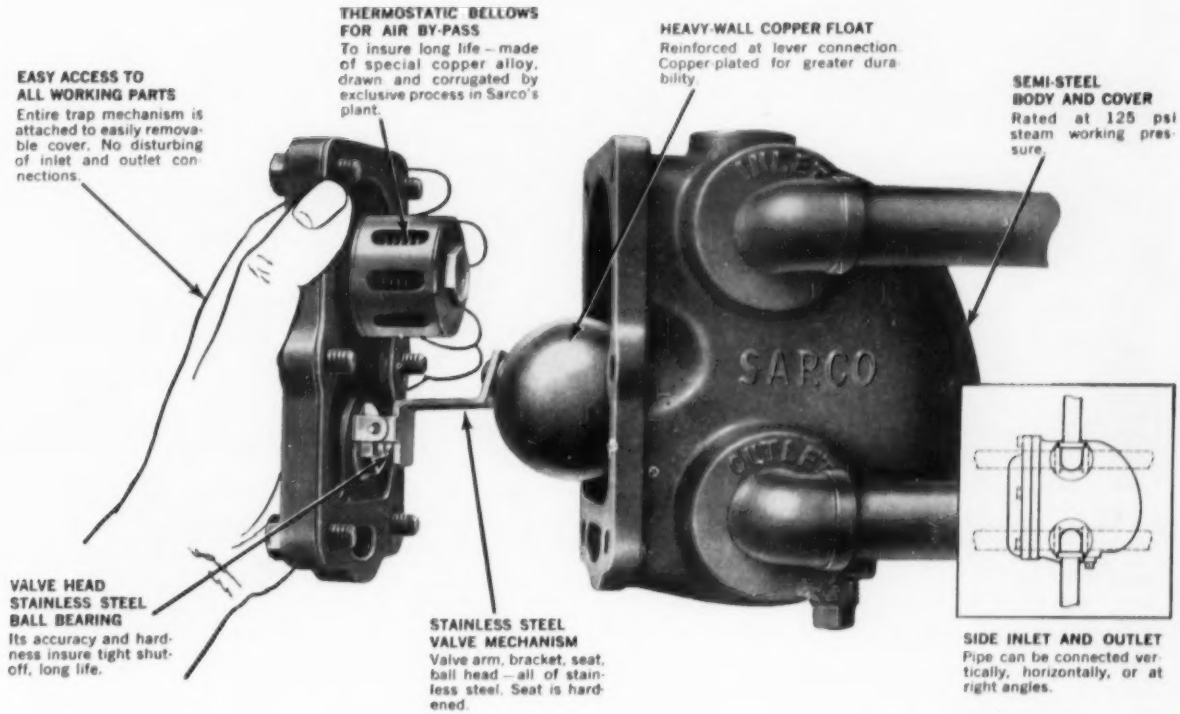
17—ADJUSTABLE VALVE is packless, corrosion resistant

Improved control of unit conditioners, unit ventilators, and convectors is said to be provided by the 4-in. Powertop. Features incorporated in this pneumatic valve are designed to increase its adaptability, accuracy and life. Foremost among them is an externally adjusted and easily accessible Monel spring with a 5 psi range. — It may be adjusted to close between 5 to 12 psi top pressure to enable a single valve to meet a variety of conditions. Lower housing of the valve is of high impact phenolic to eliminate electrolytic corrosion between housing and internal metal parts and to resist heat distortion over 300 F. The silicone diaphragm is 10 sq in. in area, providing

Now...more trapping value for your money!

NEW SARCO FLOAT-THERMOSTATIC STEAM TRAP

with improved engineering features


EASY ACCESS TO ALL WORKING PARTS
Entire trap mechanism is attached to easily removable cover. No disturbing of inlet and outlet connections.
THERMOSTATIC BELLOWS FOR AIR BY-PASS
To insure long life – made of special copper alloy, drawn and corrugated by exclusive process in Sarco's plant.
HEAVY-WALL COPPER FLOAT
Reinforced at lever connection. Copper-plated for greater durability.
SEMI-STEEL BODY AND COVER
Rated at 125 psi steam working pressure.
SARCO
VALVE HEAD STAINLESS STEEL BALL BEARING
Its accuracy and hardness insure tight shut-off, long life.
STAINLESS STEEL VALVE MECHANISM
Valve arm, bracket, seat, ball head – all of stainless steel. Seat is hardened.
SIDE INLET AND OUTLET
Pipe can be connected vertically, horizontally, or at right angles.

This new, improved Sarco Float-Thermostatic Steam Trap Type FT discharges condensate at steam temperature continuously and without shock.

Recommended to drip steam mains, unit heaters, blast coils, heat exchangers, and other allied process equipment, requiring accurate temperature control.

Air Binding Impossible – equipped with separate thermostatic air vent, which removes automatically and immediately all air and incondensable gases reaching trap. Balanced pressure vent self-adjusts to all operating pressures. Its location above condensate level permits discharge of air and gases reaching trap after start-up. Does not require adjustment when pressures change.

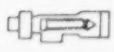
Sizes – ¾ and 1"
For steam pressures – 0 to 125 psi

Write for Bulletin 455-B to Sarco Company, Inc., 635 Madison Avenue, New York 22, N. Y.

SARCO

REMEMBER— only Sarco makes all types

Thermostatic Steam Traps



Liquid Expansion Steam Traps

Thermo-Dynamic Steam Traps

Float Thermostatic Steam Traps

Camlift Bucket Steam Traps

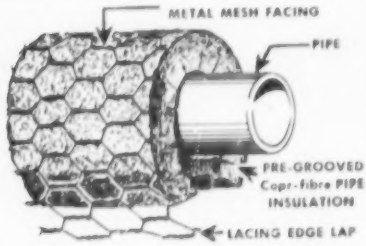
For more data circle 534 on Post Card

greater closing power than previous models of the valve. The diaphragm housing is lower, enabling the valve to fit into a smaller space.

Also new in the valve is a molded swivel (poppet) and a stem guide with two bearing points to provide perfect alignment in the valve seat and tight shut-off, and to prevent noise or "chattering" at differential pressures to 25 psi. The valve utilizes company's duo-seal construction. Instead of packing, the valve uses a seamless bronze bellows as a primary seal and a spring-loaded Neoprene quad ring as a secondary seal. Further details are in Form P-55. Powers Regulator Co.

18—PIPE COVERING offers one-piece application

Copr-fibre Lace-On Pipe Covering is announced as a felted mineral insulation which gives a one-piece application at minimum first in-place cost. It is reinforced with a metal mesh facing horizontally laced together around the pipe,



and requiring no extra wire. The insulation is pre-grooved on inside surface which allows an easy wrap and a tight fit around pipe. After application, the covering can be jacketed with aluminum or galvanized sheet metal for exterior application. Temperature range for which Lace-On is recommended is from 100 to 1200 F. Thicknesses available range from 1 to 5 1/2 in. It is applicable on 2- to 14-in. and larger sizes of pipe. K factor is 0.26 at 100 F. Manufacturer says it is chemically neutral, moisture resistant, stable, incombustible, and it will not cause or accelerate corrosion. Forty-Eight Insulations, Inc.

20—SAFETY VALVE protects against turbine over-speed

An added feature for protection against over-speed of the low pressure turbine in case of failure of the intercept valve to close on loss of turbine load is announced in this standard reheat header spring loaded safety valve line. This feature consists of an air lift cylinder added to the conventional spring loaded valve for lifting valve to its full discharge capacity at any pressure down to zero. The air lift cylinder is designed to open valve to its full capacity in less than 1/10 sec. The air lift mechanism is controlled by an overspeed switch on the turbine which acts immediately when an over-speed due to loss of load takes place. By opening of reheat safety valves immediately on an increase in turbine speed, the pressure in header is relieved so that cause of over-speed is removed. Crosby Valve & Gage Co.

21—PRECIPITATOR CONTROL adjusts electrical voltage

The Transistomatic is introduced for use on this manufacturer's Cottrell electrostatic precipitators. It serves to continuously adjust voltage to the fluctuation of the gas stream carrying the dust particles. Based on transistorized circuitry, the unit is said to embody a "sensing" principle that integrates total current in relation to time, providing a dynamic, continuous system of evaluating the rate of surge current. Western Precipitation Corp.

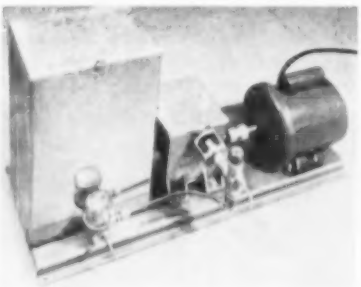
22—PORTABLE BENDER for 3/4-in. rigid steel conduit

Newest of this manufacturer's Powr Jack line, the Model PJ100 Redege Benfield Bender is designed to bend 3/4-in. Sherarduct and other types of rigid steel conduit, as well as 1-in. Xduct Junior metallic tubing. This one-piece bending tool utilizes a two-position foot treadle booster step to provide a means of constant, heavy foot leverage for smooth radius bends. Other features include an integral back pusher to true up and straighten bends, and a safety collar for protection of the handle threads. National Electric Products Corp.

19—INJECTOR PUMP feeds metered chemicals into lines

Chemical Injector Pump Model SAC-4000 is designed to inject measured amounts of liquid chemicals into flow lines and pressure vessels, against pressures to 1200 lb. The pump is operated by a 1/4 hp 1750 rpm electric motor; the 50 to 1 reduction worm gear assembly operates the cross head drive mechanism to move the piston injectors. There may be one or two piston injector assemblies on each pump; each piston may inject measured amounts of a separate chemical at the same time. Output may be pre-set to inject from a few ounces to 40 gal in a 24 hr period, with one injector head, by regulating the length of the piston stroke and piston size.

The pumps are available with three standard size piston-injector head assemblies: 1/4-in. piston pumps against 1200 lb pressure; 3/8-in. against 500 lb; and 1/2-in. against 250 lb. Each piston has a separate calibrated stroke adjustment which may be locked in position. By using variable speed motors and



timers the discharge output may be further regulated. Explosion proof motors, air-gas turbines or light duty gasoline engine may also be used to drive the pumps. Pistons and check valve assemblies are stainless steel, pump head body castings are Meehanite, and the chevron packing is compounded rubber. Special injector heads may be made of stainless steel, bronze or plastic. Texsteam Corp., Div., Vapor Heating Corp.

Reader Service Cards on pages 123–124 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

23—PURIFIERS designed to withstand high pressures

These new additions to company's line of Hi-eF Purifiers are designed to withstand pressures up to 15,000 psi for steam, air and process vapor and gas lines. They are primarily for high pressure applications in chemical, petroleum, synthesis gas, petrochemical, air reduction plants. Pressure parts are of special alloy steel with special gaskets and pipeline connections. To date, the largest of these new pressure vessels is a 6-in. size, while 12,050 psig is the maximum service pressure announced. Manufacturer states that the unit uses no moving parts, filter or mesh screens, but operates by a two-stage principle of separation that employs controlled centrifugal force to guide the entrainment-laden vapor through a series of vanes and baffles. The V. D. Anderson Co.

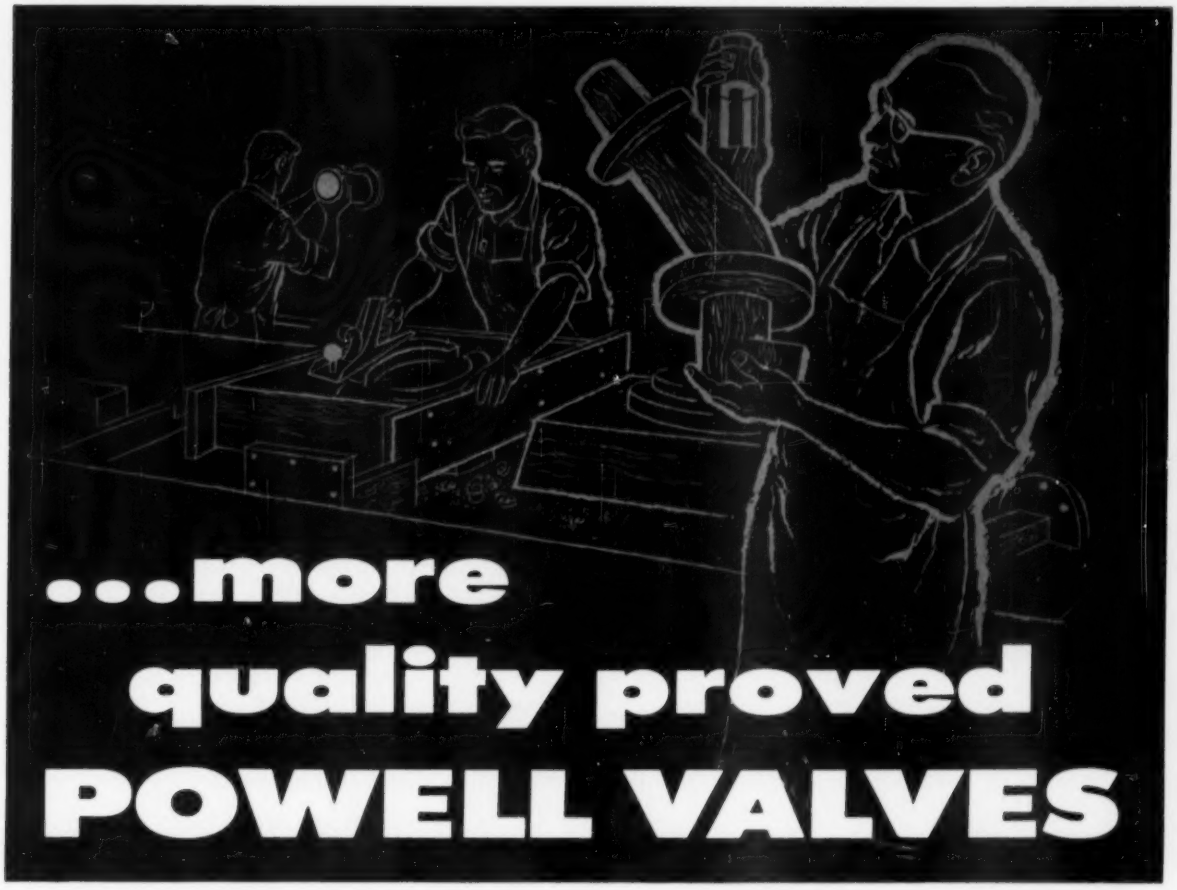
24—INSTRUMENT measures vibration, finds its cause

IRD Model 600 Vibration Analyzer is announced as providing instrumentation to 1) measure the amplitude or velocity, the frequency and the phase of vibration; 2) study separately any frequency

present in a complex system; 3) pinpoint the part causing the predominant vibration, and 4) correct the cause of vibration by balancing in place, without dismantling of machinery. The analyzer measures vibration amplitude from 0.1 to 100 mils, velocity from 0.03 to 30 in./sec, and frequency from 450 to 150,000 cpm. A continuously variable filter is incorporated to permit separate analysis of each frequency. Other components include a velocity type vibration pickup and a stroboscopic lamp. The instrument is housed in a case with carrying handle. International Research & Development Corp.

25—STEAM HOSE is wire-reinforced and burst-proof

Known as W.B. Steam Hose, this wire-braid reinforced, burst-proof steam hose is announced for applications in saturated steam service at pressure to 200 psi, or for superheated steam to 385 F. Reinforced construction serves to prevent explosive rupture in case of hose failure. A Neoprene cover provides resistance to heat, abrasion and petroleum products. Hose is designed for high pres-



...more quality proved POWELL VALVES

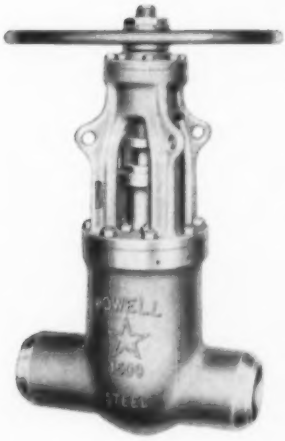
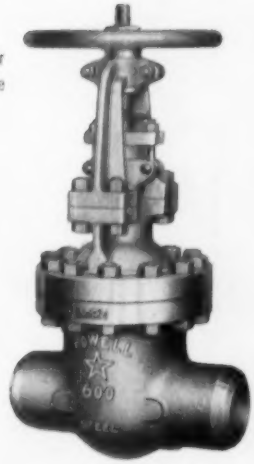


Fig. 11303—1500-Pound Cast Steel Pressure Seal Gate Valve.

Fig. 375—Bronze Gate Valve for 200 Pounds W.S.P. Union Bonnet. Inside Screw Rising Stem.

Fig. 11365—Steel Pressure Seal Horizontal Lift Check Valve for 1500 Pounds W.S.P.

Fig. 6003-WE—Steel Gate Valve for 600 Pounds. Welding Ends. Outside Screw Rising Stem and Yoke.



for quality-crafted flow control

Ask your Powell Valve Distributor for the facts about quality-proved bronze, iron, steel and corrosion-resistant valves. Whatever your flow control problem, there's a Powell Valve to solve it.

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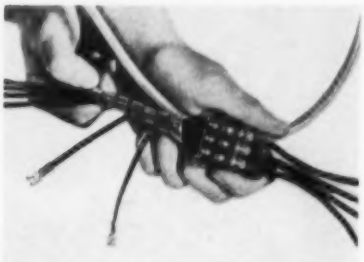
sure steam service, auxiliary fire fighting, and for syphoning or drilling machines. It is also suggested for flexible steam connection of two lines or for supplemental steam supply. Other applications include heating bituminous binders, and flue and still cleaning. Hose is built around a tube compound of special heat-resisting rubber for longer life under high-temperature live steam. Reinforcement is provided by one or two braided plies of high-tensile steel wire, each covered by a layer of heat resistant rubber. Seven standard sizes range from ½ to 2½ in. ID. Acme Rubber Mfg. Co., Div., Acme-Hamilton Mfg. Corp.

26—PLASTIC WRAPPING goes around cable easily

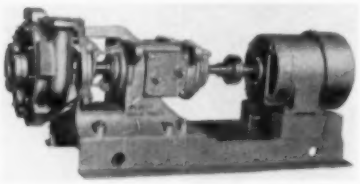
Amp-Spirap is announced as a spirally-cut plastic wrapping that eliminates cable lacing, insulation damage and pulling of wires through spaghetti tubing. It



is readily applied to wire bundles of any size up to 3½-in. diam, and permits individual wires to be entered or led out at any point. Manufacturer points out that it can be unwound to let new wires be added, and that it holds wires together tightly, but permits flexibility for forming cable. A sample is offered. Amp Inc.

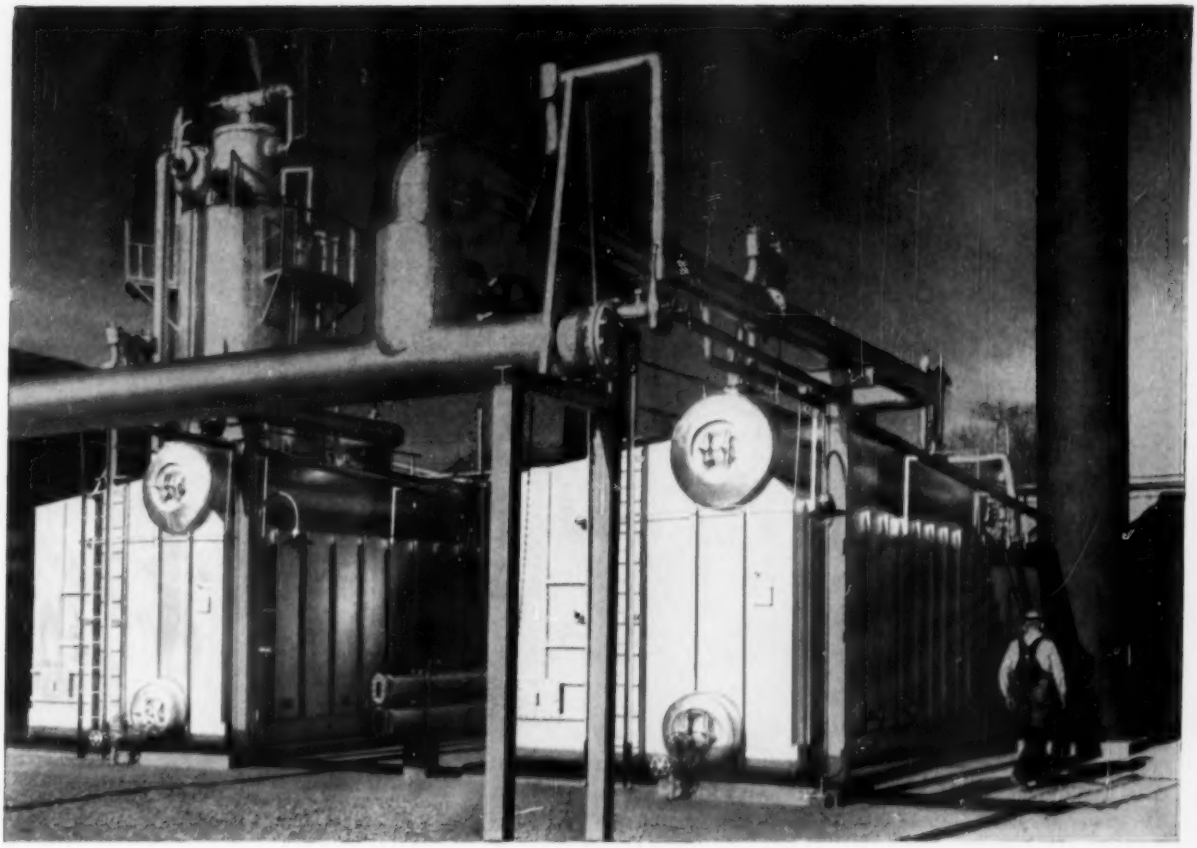
27—CENTRIFUGAL PUMPS with operational advantages

The H series of single stage, end suction, centrifugal pumps, are available in three types of water-ends: Type HR (shown) for handling abrasive mixtures where head is limited; Type HC with split bearing stand for corrosive applications; and Type HF for either abrasive or corrosive applications where high pressures are developed. The water-end



or casing can be rotated to any one of four positions to provide discharge of pumped material as desired.

Several advantages are stressed by manufacturer, first, that oil or grease lubrication is optional. Also, these pumps have a simple, readily accessible arrangement which provides radial adjustment of the shaft to assure concentricity of the shaft through the stuffing box. All assemblies are made by bolts and nuts — there are no tapped holes. If nuts cannot be readily loosened, they can be burned off with a torch, it is pointed out, and without damage to the pump. Slippage seal adjustment is han-



PACKAGED STEAM by FW

helps load more than 7,000,000 gallons of oil in less than 3 months

When U. S. refiners recently were required to meet a sudden, extended demand from Europe for oil, one of the key points of supply was the Magpetco Terminal of Magnolia Petroleum Company. With storage capacity for some 4½ million bbl of petroleum products, this southeastern Texas tank farm was a "natural" for emergency use as a crude oil outlet point – 7,000,000 gallons of crude oil were loaded in less than 3 months.

The two Foster Wheeler Packaged Steam Generators shown above not only met all the normal load requirements but demonstrated ample reserve capacity for emergencies. They provided a reliable source of steam which was essential to operate the many large reciprocating pumps and to heat heavier oil in the storage tanks to facilitate pumping.

Chosen by Magnolia engineers to replace outmoded steam equipment at the terminal, the units are installed outdoors. Casings are of all steel welded construction with weatherproof insulation over the drum ends. Each unit delivers 30,000 lb of steam per hour at 150 psi. Dimensions are: 10′ x 28½′ x 12′ high.

FW Packaged Steam Generators are available in capacities from 10,000 to 62,500 lb/hr and pressures to 1300 psi. For complete information, send for Bulletin No. PG-55-3. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

FOSTER WHEELER

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NOW···GLOBE OFFERS···
two new INTERCHANGEABLE trays for support of cables, wiring and tubing

★ Engineered for uniform design and easy installation
★ Steel or aluminum construction
★ Complete accessories for SPEEDIER Installation
★ No sharp edges to damage cables
★ Complete interchangeability

Now, for the first time, two types of cable trays, one a ladder type and the other a basket type, are available to be used INTERCHANGEABLY at any given location, depending on the type and weight of the cables to be suspended. The advantages of each type tray can thus be used to the fullest extent. Globetray, the ladder type, is intended for use where festooning is not a problem, while Cable-Strut, the basket type, is intended for the support of communication wire, instrument tubing and control cables in automation applications.

These two cable trays have been thoroughly field tested in hundreds of large industrial installations, in new plant construction, in power plants, in modernization, and for power distribution in all types of manufacturing processes. A new catalog, just off the press, gives full information and installation techniques. Ask for your FREE copy today.

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PRODUCTS DIVISION

The **GLOBE** *Company* MANUFACTURERS SINCE 1914

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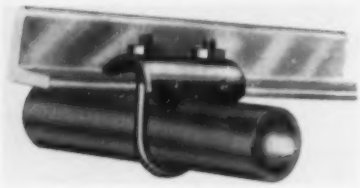
dled with a common wrench. All models in the H series are available in sizes from 1 to 16 in. for heads in some cases up to 250 ft or more and capacities to 10,000 gpm. Nagle Pumps, Inc.

28—CONDUIT HANGER designed for greater stability

The Ramco Type X is announced as a right angle conduit pipe hanger which presents a new concept in such pipe fastenings. Unlike supports which cannot maintain constant pressure under



vibration or thermal variations, this type hanger is said to retain constant effective clamping tension by the spring action designed into the saddle. This feature is the safety-plus factor, company notes, and makes this hanger suitable for heavy duty industrial applications. The Type X saddle is made of heavy gage steel. Sharp biting edges at the corners are further apart than U-bolt legs to provide self-equalizing bite pressure and unusual stability. Hanger can be used with standard pipe or E. M. T. conduit for mounting on structural flanges up to ⅞ in. thick. Each hanger is furnished with standard U-bolt and nuts assembled ready for use. It is available in ¾- to 2-in. pipe sizes. Ramco Mfg. Co.

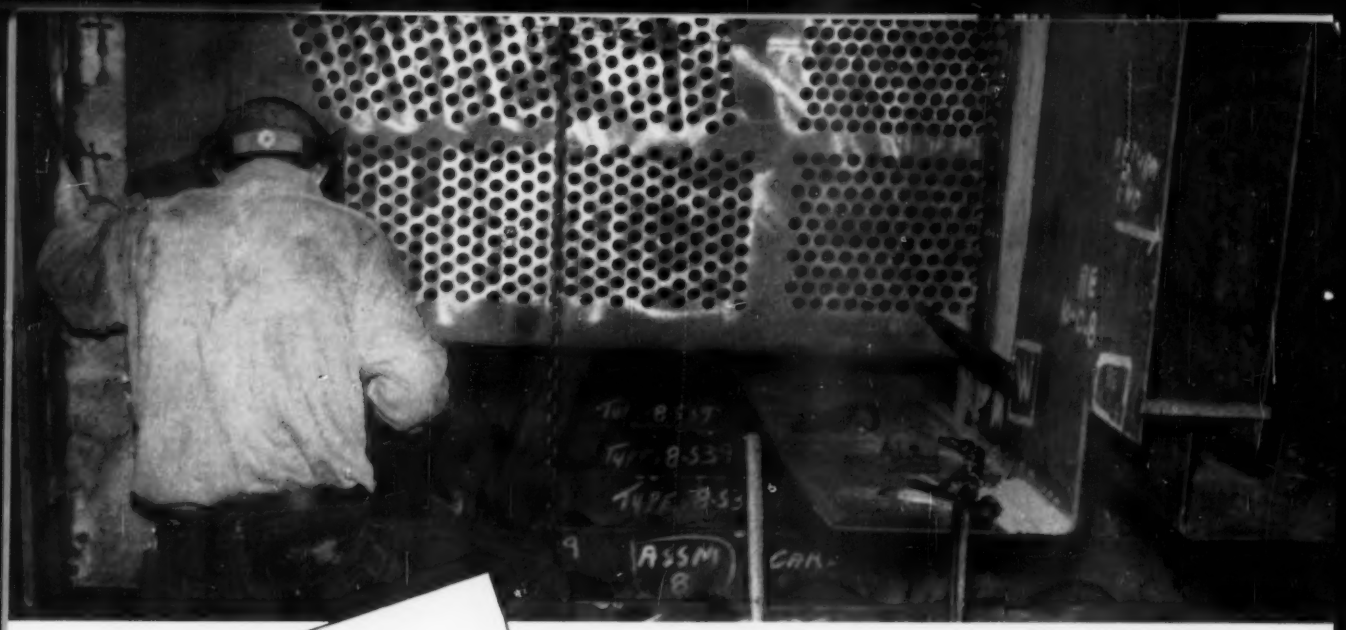
29—REFRIGERATION OIL works with many refrigerants

Suniso 3G is announced as an all-temperature oil designed to work well with all modern refrigerants, including Freon-22, Isotron-22, and Genetron 141. The lower floc point, greater stability and increased copper-plating resistance of Suniso 3G, company says, permits more efficient operation of compact modern refrigeration units. Sun Oil Co.

30—THERMAL RIBBON detects the surface temperatures

The Thermal Ribbon provides a means of electrically detecting the temperature of the surface to which it is attached. Described as extremely flexible and with negligible thermal lag, Thermal

Ribbons are designed for use in electronic equipment, and other applications where it is necessary to accurately monitor or control temperatures of surface areas. The ribbon consists of a resistance element of high nickel content alloy



Another CONDENSER designed and built by MARIND

In ever growing numbers, Marind Condenser installations are earning a well deserved reputation for efficient, dependable performance. Designed and built by thoroughly experienced engineering and manufacturing personnel, Marind power equipment products enjoy a reputation for outstanding quality. We have in process of construction units to suit turbo generators to 156 megawatts, and are capable of processing steam surface condensers to any size.

Industrial Products Division

MARYLAND SHIPBUILDING & DRYDOCK COMPANY

BALTIMORE 3, MARYLAND • *Representatives in Principal Cities*

MARIND

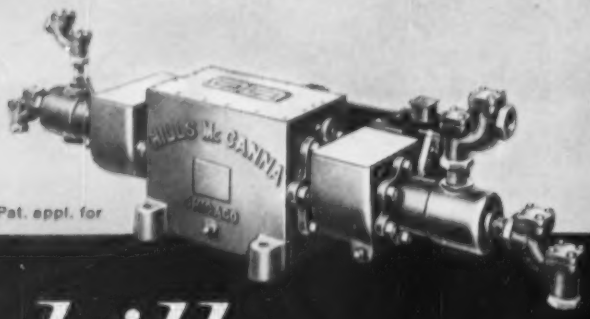
STEAM CONDENSERS AND AIR EJECTORS

for stationary power plants and marine service

Accurate Proportioning of Fluids

Hills-McCanna Metering and Proportioning Pumps

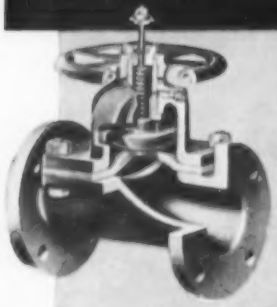
Hills-McCanna Proportioning Pumps are designed for dependable precision metering and simplified maintenance. Ranging in capacity from a few cc to hundreds of gallons per hour, they may be adapted to automatic operation. Write for the valuable booklet "Precision Proportioning Pumps" for complete information.



Pat. appl. for

hills-mccanna company

THE PEOPLE WHO KNOW AND CONTROL FLOW



DIAPHRAGM VALVES

...provide leak-tight, dependable valve performance for corrosive services, slurries, liquids, gases, air and water; feature simplified in-line maintenance, exclusive sealing bead diaphragm. Write for informative catalog on complete valve line.

Hills-McCanna Company, 2360 W. Nelson Ave., Chicago 18, Illinois

For more data circle 540 on Post Card

wire encased in a flexible outer covering. Less than 0.020 in. thick, the ribbon may be cemented to flat, cylindrical, or irregular surfaces. Self-adhering types are also available. Designed to operate over wide temperature ranges and under severe physical conditions, the ribbons are made in several shapes and sizes. Minco Products, Inc.

31—ENGINEER'S TAPE has two scales on its blade

For those who work with both eighths and tenths measurements, this tape combines both scales on one side of the blade, enabling instant conversions from eighths to tenths. Of white enameled steel with black numbers, the blade is divided in half by a double line, with the regular inch and eighth graduations on one edge; the tenths and hundredths on the other. The tape comes in both 50- and 100-ft lengths. The shorter length sells for approximately $6.50. Evans Rule Co.

32—FOOTLESS DRIVE UNIT for rugged industrial duty

Type VEV Varidrive is a compact, footless variable speed motor with NEMA Style C or P face-type mounting. It is reported to feature quick, accurate

alignment to driven equipment. Versatility of this type of mounting suggests use of the Type VEV for turbine pumps, mixers and similar applications. The unit is designed for rugged duty and is available from ¼ to 30 hp, in ratios up to 10:1 and can be had with Varitrol automatic control or remote controls of the mechanical or electrical type. U. S. Electrical Motors Inc.

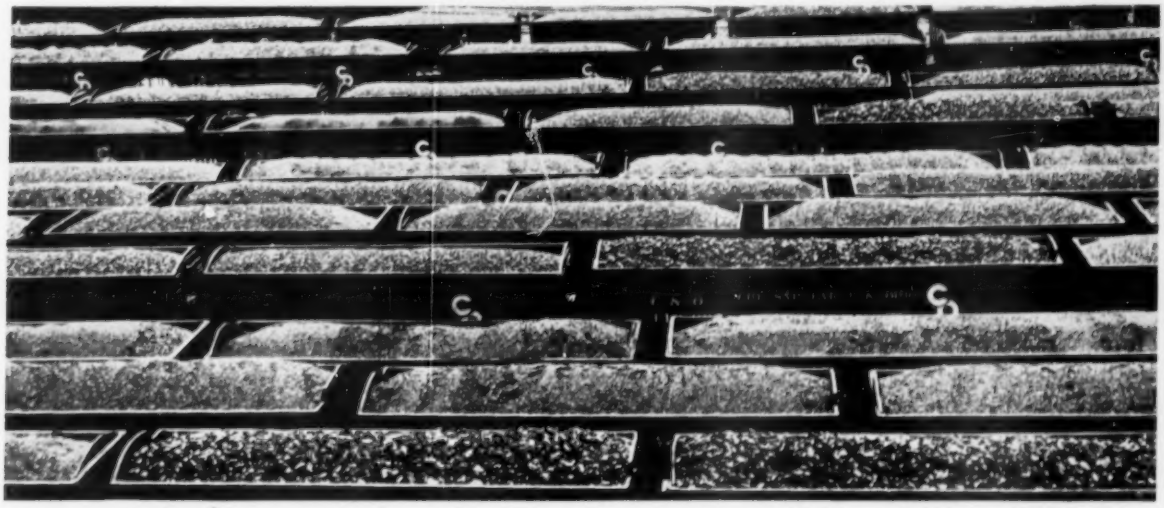
33—INSULATED WIRES for general purpose wiring

Type RHH wires, insulated with silicone rubber and having an asbestos braid, come in the same size range as standard butyl-insulated Type RHH wires — No. 14 AWG through 6 AWG — and are listed by Underwriters' Laboratories for general-purpose wiring, company states. Because silicone insulation has greater resistance to heat, these wires have longer life, it is noted, and their added heat resistance makes them suited to power and lighting installations in industrial plants and in commercial buildings with heat-problem areas. The insulated wires are rated for 600 v, 90 C operation, General Electric Co.

more Equipment News page 135

WHY CHESSIE'S RAILWAY IS FIRST IN COAL

SUPERIOR COAL. This large battery of washing tables is an example of the modern methods used by producers on the C&O. The naturally superior coals found in the Chessie area can be sized and processed to meet your own particular requirements.

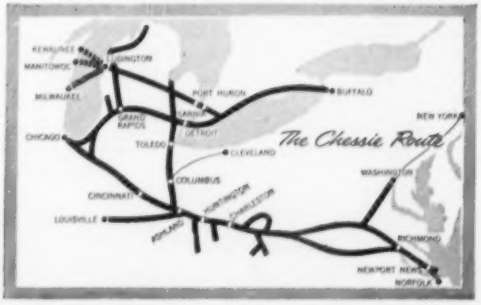


SUPERIOR SERVICE. With the world's largest fleet of coal cars, C&O's accelerated repair program continues to keep them in better than 99% good order. Plenty of cars, plus ample motive power and modern yards and signal systems assure prompt and efficient service.

For dependable sources of top quality coals, contact coal producers on the C&O. And for specific help in meeting your own fuel requirements, write to: R. C. Riedinger, General Coal Traffic Manager, Chesapeake and Ohio Railway Company, Terminal Tower, Cleveland 1, Ohio.

Chesapeake and Ohio Railway

WORLD'S LARGEST CARRIER OF BITUMINOUS COAL



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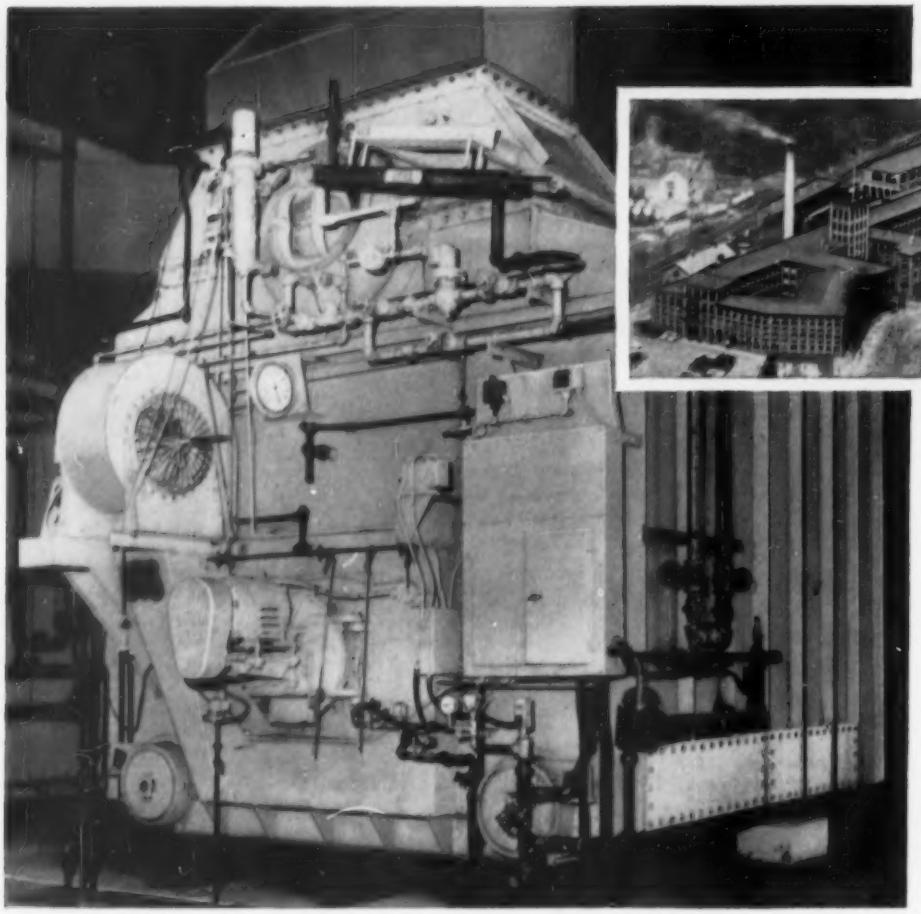

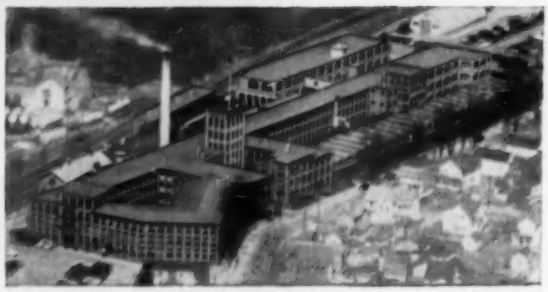

AERIAL VIEW OF TORRINGTON'S EXCELSIOR PLANT, TORRINGTON, CONN. Torrington is world renowned for its manufacture of bearings, needles, bicycles and metal specialties.

ONE OF TWO UNION TYPE MH PACKAGED BOILERS serving Torrington's Excelsior Plant. Equipped for oil firing, this unit has a steam capacity of 15,000 lbs./hr. at 250 psi.

Torrington racks up $12,500 savings in year with first of two Union Packaged Boilers

Selected because its "construction and design appeared better than others . . . physical size fitted into plans," a 20,000 lb./hr. Union Type MH Steam Generator was installed in the Excelsior Plant of The Torrington Company in October, 1955.

Providing steam for process and space heat, the new boiler quickly proved its worth. In October 1956, as a second MH Unit (15,000 lbs./hr.) was placed in operation, Torrington had this to say about the first: "Estimated savings for the first year are $12,500, as compared to our old coal burning hand fired boilers."

Throughout industry, numerous concerns report like economies as the result of modernizing with modern Union Type MH Steam Generators.

Completely shop-assembled at Union Iron Works for delivery via rail or truck, Union Packaged MH Units are patterned after larger but similar field erected Type H Boilers, originated by Union over 17 years ago.

With standard units designed in 13 sizes from 10,000 to 50,000 lbs. of steam per hour, Union Packaged Steam Generators can be readily equipped to handle multitudes of needs formerly requiring costly field erection and special engineering.

GET FULL DETAILS including cut-away illustrations, tube layouts and dimension tables by writing for Bulletin MH-353.

UNION

UNION IRON WORKS
ERIE, PENNSYLVANIA

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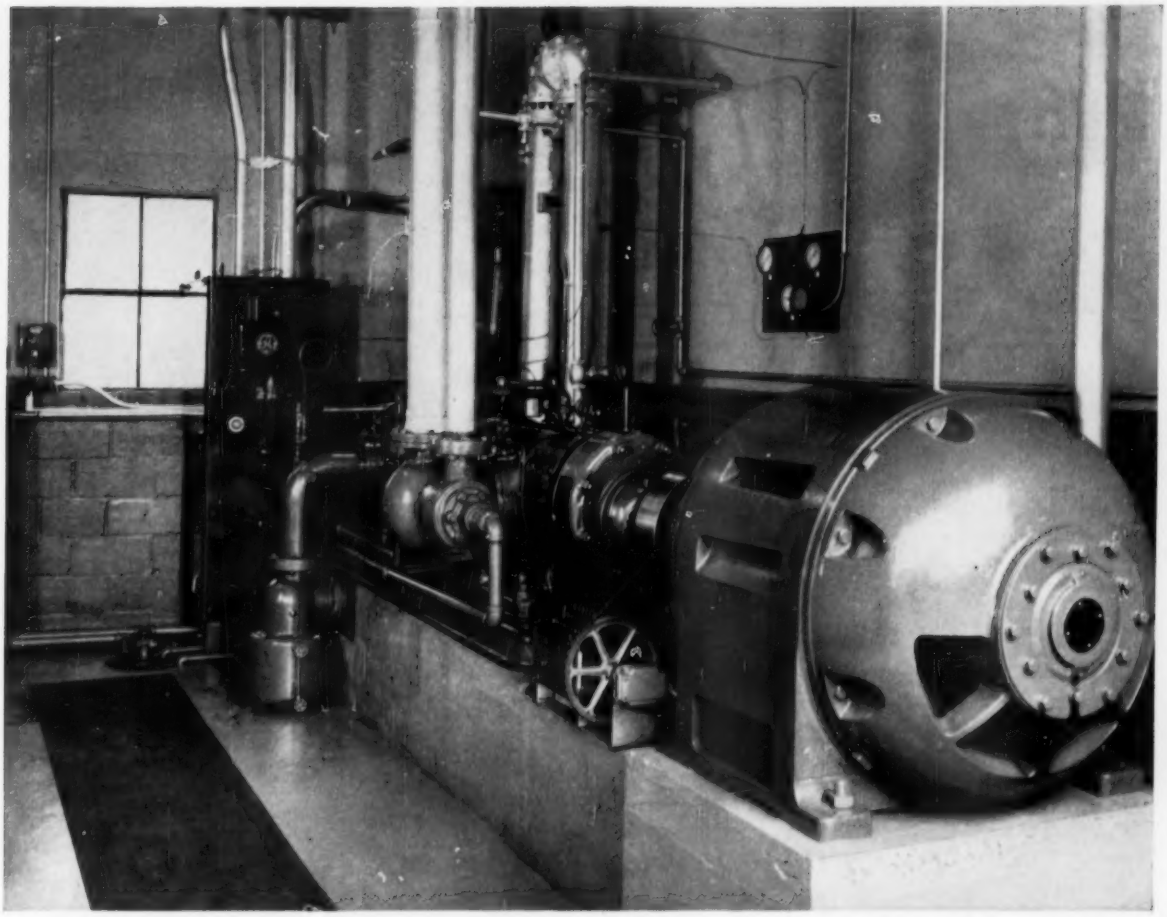

Fuller Rotary Two-Stage Compressor, C135-135H. Capacity 680 c.f.m., 100-lb. pressure, 690 r.p.m., 150 hp. motor.

16,000 HOURS OF OPERATION WITH NO MAINTENANCE

Empire Steel Castings, Inc., Reading, Pennsylvania, installed a C-135-135H Fuller Rotary Two-stage Compressor in April 1953. After 32 months—approximately 16,000 hours of operation—the compressor received a routine inspection, when a new set of blades was installed in the higher-pressure cylinder.

The Empire engineers report no downtime since replacement, although they've added 4,000 operating hours. Prior to switching to Fuller, their former experience with compressors was a different story—as many as several overhaulings in one year. With Fuller equipment furnishing a constant high capacity air supply, production costs have been greatly reduced.

Here's how Empire uses compressed air:

- In the molding department, supplying all air for pneumatic rammers, all squeeze and jolt machines, automatic set-out and lifting apparatus of mold conveyors, automatic shake-out machines, mold cleaning and spraying equipment.
- In the core department, for ramming equipment, spraying and torch drying equipment, core oven operation as well as core blowing equipment.
- In the cleaning department, pneumatic chipping hammers and grinders, blacksmith requirements, sand-blasting, pressure testing and miscellaneous tools.
- In the heat-treating department, heat treating furnace operation and cooling equipment.

To get all the facts and engineering data, write today for Bulletin C-5A.

C-298
3662

FULLER COMPANY
150 Bridge St., Catasauqua, Pa.
SUBSIDIARY OF GENERAL AMERICAN TRANSPORTATION CORPORATION
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Fuller

PIONEERS OF HIGH-EFFICIENCY VANE TYPE ROTARY COMPRESSORS SINCE 1930

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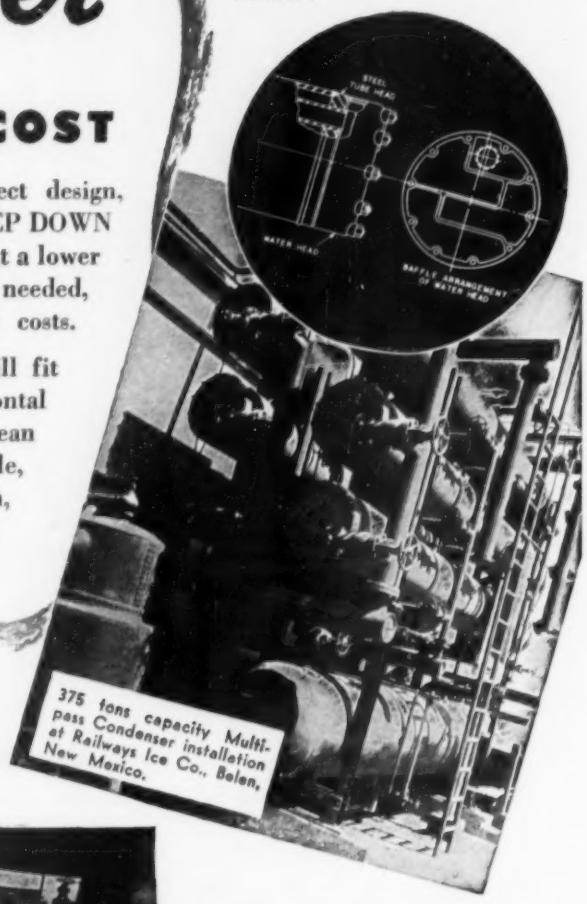
$ave Power and REFRIGERATION COST

Vogt Condensers, because of their correct design, STEP UP the rate of heat transfer and STEP DOWN head pressures. With the liquid delivered at a lower temperature, smaller compressor capacity is needed, saving in original as well as operating costs.

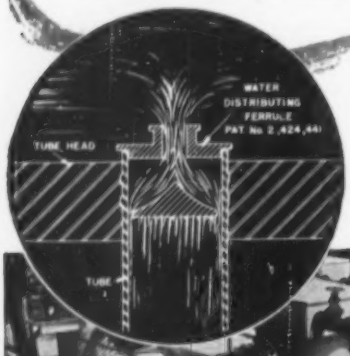
One of the two basic types illustrated will fit your operations exactly. Install Horizontal Multipass (closed type) for use with clean waters. Where the water is hard, forms scale, contains mud or promotes fungus growth, Vertical Single Pass (film type) which can be cleaned in operation, are recommended.

Horizontal Multipass Condensers
(Closed Type)

Water circulated in tubes traverses the length of the unit a number of times as determined by baffles in the heads.

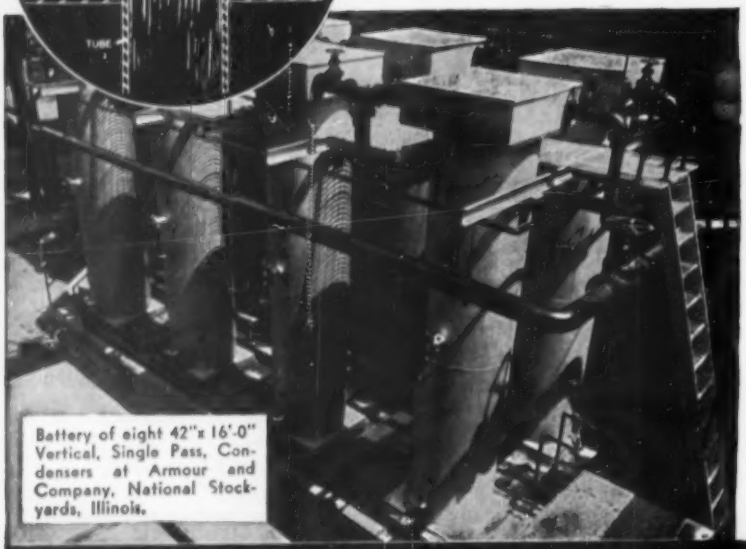


375 tons capacity Multi-pass Condenser installation at Railways Ice Co., Belen, New Mexico.



Vertical Single Pass Condensers
(Film Type)

Patented ferrules give equal distribution of water to and over the surfaces of all tubes in a unit.



Battery of eight 42"x 16'-0" Vertical, Single Pass, Condensers at Armour and Company, National Stockyards, Illinois.

HORIZONTAL and VERTICAL TYPES SHELL and TUBE CONDENSERS For Every Service

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Address Dept. 24A-RIPE

HENRY VOGT MACHINE COMPANY
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1008 W. ORMSBY ST., LOUISVILLE 10, KY., U.S.A.
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Vogt REFRIGERATION CONDENSERS

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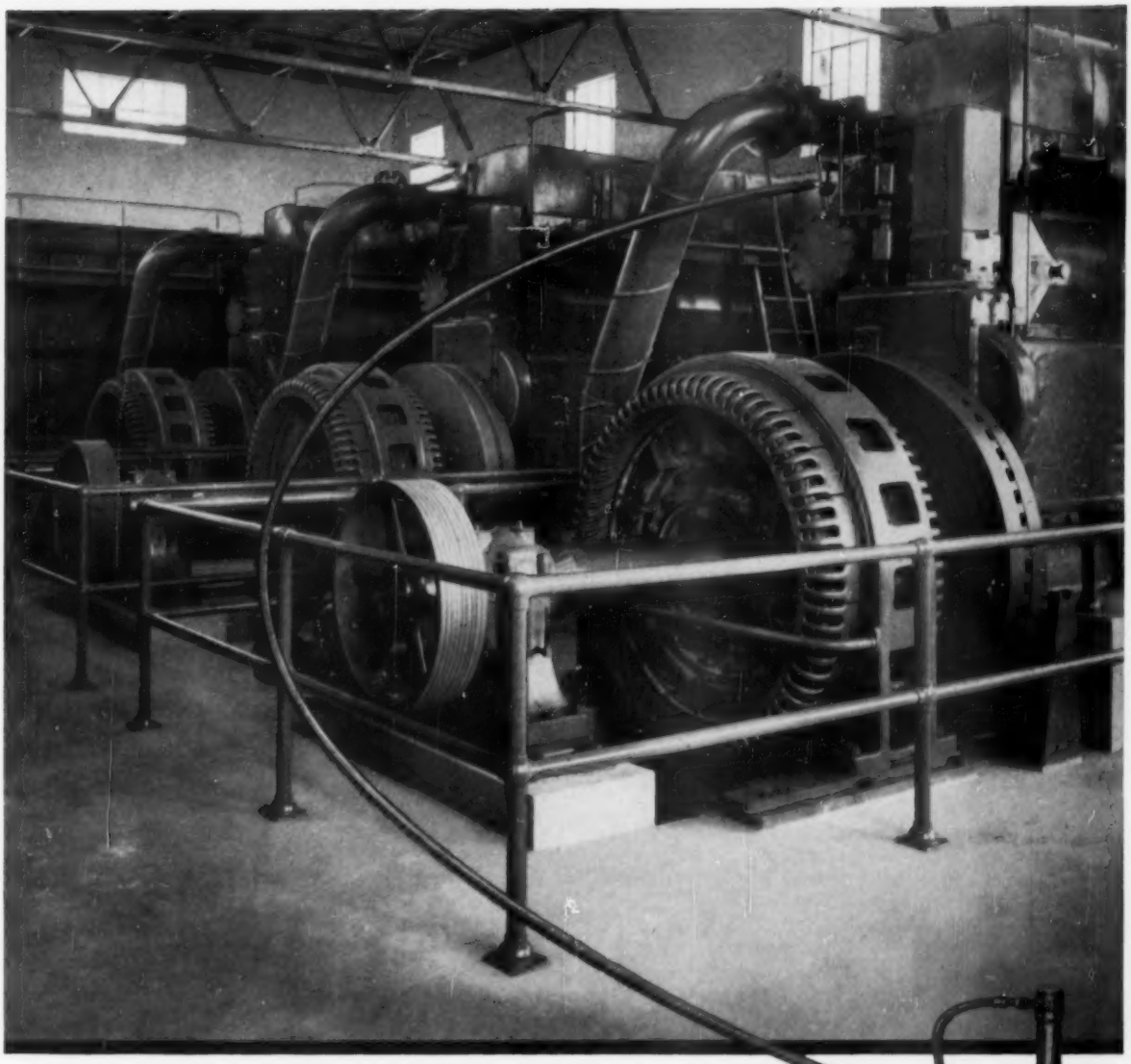

NO STUCK RINGS!

Stop the formation of varnish, sludge and carbon in your Diesels and *keep it stopped* with Sinclair RUBILENE®, the high viscosity index oils proved by over 35 years in industrial Diesel applications. RUBILENE earns its reputation by its performance under continuous operation and heavier loads. It fights deposits and gives better protection to cylinders, pistons, rings and other vital moving parts. Your Diesel stays on the job longer . . . service time is cut 'way 'way down!

Let RUBILENE help solve your lubrication problems. Regardless of the make or age of your Diesel, where a high VI oil is needed, there's a member of Sinclair's RUBILENE or RUBILENE HD family that meets your requirements exactly. Call your local Sinclair Representative for further information or write for free literature to Sinclair Refining Company, Technical Service Division, 600 Fifth Ave., New York 20, N. Y. *There's no obligation.*

SINCLAIR RUBILENE OILS

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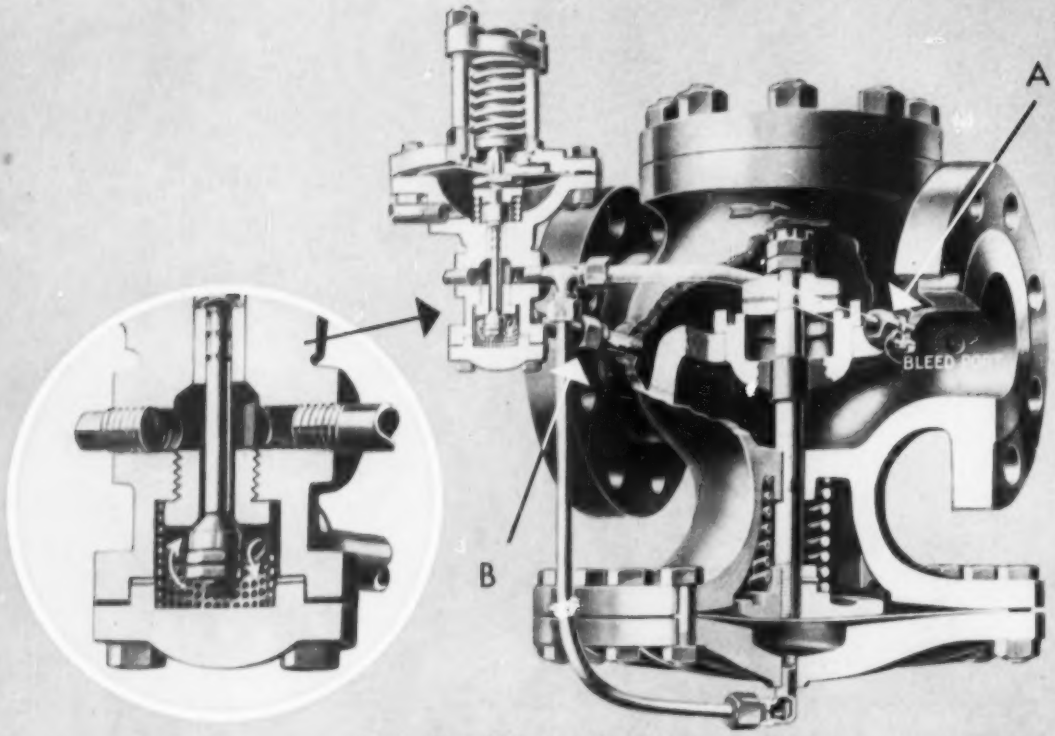
VALVE TIPS:

Advantages of External Pilots in Automatic Regulating Valves



Spence Type ED Pressure Regulator

"Maintenance-free, trouble-free, install-and-forget." They're all pretty phrases, but every engineer knows from experience they don't apply to regulating valves. Any valve designed to control temperatures or pressures within tight limits can be affected by dirt or other foreign matter in steam lines.

One advantage of the external pilot mounting shown above is simplified maintenance. Trouble shooting is faster, downtime is reduced, and tempers don't take such a beating. Here's why:

If trouble develops, it's easy to find out if it's in the pilot or the main valve. Just remove the tubing bend at A. A simple test, without any instruments or other equipment, shows where the trouble is.

If the trouble is in the pilot, you can remove it by disconnecting the unions at B. There's no need to take the main valve out of the line.

The quickest way to get the regulator functioning again is to install a spare pilot. This is easy — and in the Spence design it's not expensive to carry spare pilots. Spence pilots fit all sizes of Spence main valves. There's no need to stock an expensive inventory of pilots for each main valve size.

In the enlarged sectional drawing above, you can see how the strainer, seat and disc of the pilot are readily accessible by removing the blind flange.

If the trouble is in the main valve, here again inspection is easy. If there's dirt in the steam line, it may clog the bleed port or restriction orifices. In the Spence design these can be inspected and cleaned by merely removing the tubing connections. The seat and disc of the main valve can also be inspected easily by removing the top flange.

These maintenance advantages, plus other advanced design features, are available for a wide range of regulating applications. For information on Spence's wide range of different automatic regulating valves, write for your copy of Bulletin 1005.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York

For more data circle 546 on Post Card

Unretouched photo shows what happens when a boiler feed line is clogged with calcium carbonate deposits. CAUSE: *lack of chemical stability in feed water.* REMEDY: *properly balanced water treatment.*

LINE OF MOST RESISTANCE

A heavy build-up of scale, like that shown in the illustration, will gradually reduce the effective diameter of feed line piping, and will result in seriously restricted carrying capacity.

The line must be shut down for maintenance or replacement, causing expensive down time in the plant. Proper water conditioning will prevent this unnecessary loss. This is but one of the many problems presented by the corrosive elements of water.

In Dearborn's complete line of water conditioning products, there are treatments to eliminate scaling, sludge, carry-over, return line corrosion and other similar difficulties. Dearborn combines the proper treatment with the right control methods under technical supervision. The result: less down time and greater operating efficiency.

Dearborn Supervisory Service provides you with the three elements necessary to maintain the best in a water conditioning program—positive control, top performance effectiveness and maximum economy.

Mail the coupon for complete information.

Dearborn®

...a leader in water conditioning and corrosion control for 70 years

Dearborn Chemical Company
Merchandise Mart Plaza, Dept. PG-WT, Chicago 54, Ill.

Gentlemen: ☐ Send my copy of Dearborn Water Conditioning Program.
☐ Have a Dearborn Water Treatment Engineer call.

Name.....*Title*.....

Company.....

Address.....

City.....*Zone*.....*State*.....

For more data circle 547 on Post Card

The Yarway Impulse started a new era in steam trapping...

. . . it began in 1935, when Yarway applied a unique principle of thermodynamics to steam traps—and the Yarway IMPULSE Steam Trap was born.

Since then over 1,225,000 Yarway IMPULSE traps have proved themselves so well in service that today many other type traps are regarded as obsolete—an understandable reason why the Yarway IMPULSE type of steam trap is being imitated.

To industry, the Yarway IMPULSE trap makes possible a new high in thermal efficiency of equipment, a new low in trap operating maintenance . . . resulting in increased production and higher profits.

THE THERMODYNAMIC PRINCIPLE

This is the principle on which the Yarway IMPULSE trap design is based—that variations in temperature of water discharging through two orifices in series cause variations in pressure in an intermediate chamber between the orifices, and that these changes in pressure may be utilized to open and close the trap valve.

ONE MOVING PART

There is only one moving part in a Yarway IMPULSE trap—a small, stainless steel valve. The entire valve assembly can be replaced in 5 or 6 minutes. It is the simplest of all steam traps to service.

EQUIPMENT HOTTER, SOONER—STAYS HOT

At "start up" the little valve opens wide to discharge air and condensate continuously. This brings equipment into production in the quickest possible time. The valve then actually floats on the condensate load, maintaining highest, steady temperatures.

A YARWAY IMPULSE STEAM TRAP TO MEET EACH TRAPPING REQUIREMENT

Research and development in the Yarway Steam Laboratory, plus intensive field testing, have produced a line of steam traps—*all* of the Yarway IMPULSE type . . to efficiently meet each of the following classes of trapping service:

Normal requirements for pressures up to 600 psi call for Yarway Series 60 and 120 IMPULSE Traps in six sizes, ½" to 2".

Light loads for pressures up to 600 psi call for the ½" Yarway No. 20-A and No. 120-A IMPULSE Traps.

Heavy loads for pressures to 600 psi call for the extra high capacity Series 40 Yarway IMPULSE Trap, available in five sizes, ½" to 2½".

Highest pressure and marine requirements up to 2500 psi are met by the Yarway Integral-Strainer IMPULSE Trap, in six sizes, ½" to 2", flanged, screwed and socket weld types.

PLUS ADVANTAGES

- Small size and light weight
- Easy, low cost installation
- Minimum maintenance
- Non-freezing
- Stainless steel construction
- No adjustment of valve or seat needed for any pressure
- Low initial cost

NATIONALLY STOCKED, SOLD AND SERVICED

Over 270 Industrial Distributors stock and sell Yarway IMPULSE Steam Traps . . . and over 35 Yarway field engineers are available to help you select the right steam trap for the job.

Write for free, new bulletin "*The Why and How of Steam Trapping.*"

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY *impulse*®

...a good way to specify steam traps

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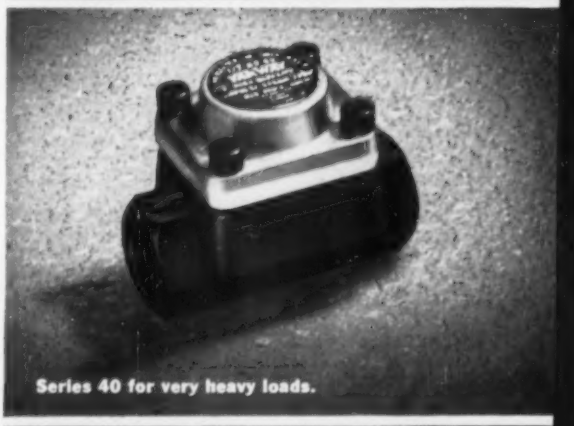
Series 60 and 120 for normal requirements.

½" No. 20-A and No. 120-A for very light loads.



Series 40 for very heavy loads.

Integral Strainer Impulse Traps for highest pressures and marine use.

Power engineers on space ships? Of course! They're going to be as essential there as in today's boiler rooms, and they had better be just as good, too. Here's a description of current space efforts

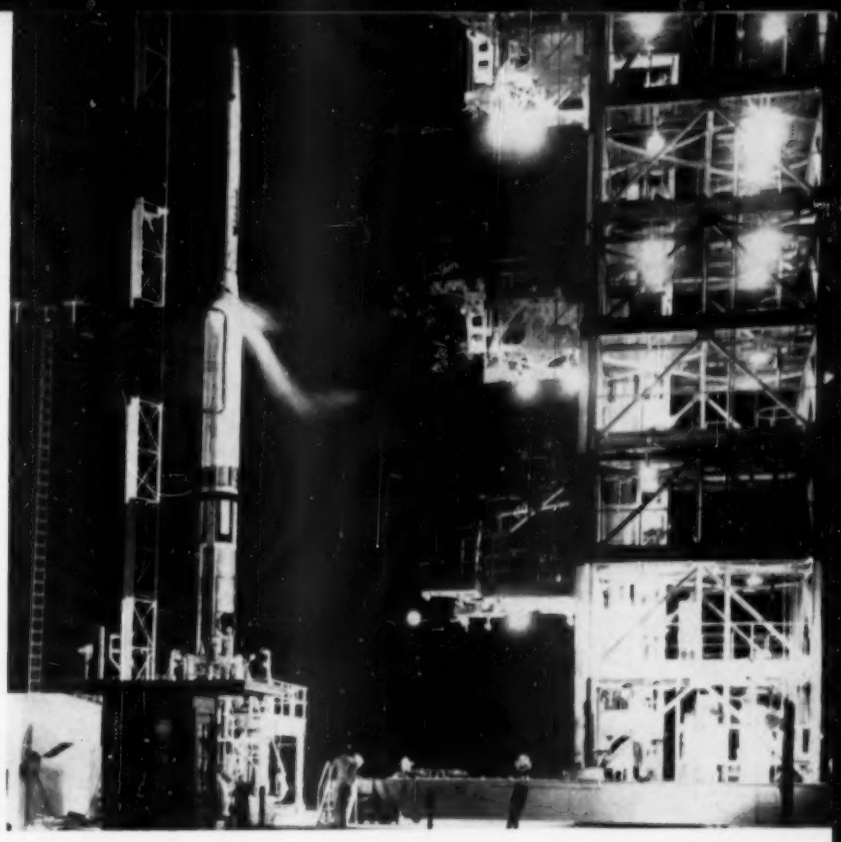


Fig. 1. Rigged for pre-launching tests, the third Vanguard test vehicle has the same external appearance as actual launching model. Note the real moon

Power Engineering Takes To Space

BROUGHT SUDDENLY from the dream world to actuality last October 4, space travel is getting a long second look from many who previously regarded it as lacking serious impact on their everyday lives. The look is revealing. Power is light and breath to humans in space. In addition it's their transportation and communication.

There will be, then, on most satellites and interplanetary space vehicles, several power systems — one or more each for propulsion, control, communication, and domestic services. These multiple systems, probably interconnected through converters, rectifiers, etc, clearly underline the vital importance of power engineering in the darkness of space.

What will be our sources of power, too far from earth to fill-er-up? We can find some of the answers by examining the propellants going into our Vanguard vehicles. They are fuels which stimulate the imagination — they seem to reek with power.

Vanguard vehicles carry into space our initial satellites, little brains designed to send back everything they see, hear and feel. A number of these vehicles are being built, with The Martin Company as the prime contractor. They are in three parts, or stages, and each stage has a different propulsion unit.

First stage is the largest and heaviest, weighing about 17,800 lb at take-off. It is 44 ft long, 45 in. in diameter. A finless tube, its guidance takes effect by varying the direction of the rocket engine thrust. The engine, shown in Fig. 2, is built by General Electric at their Rocket Engine Division in Cincinnati. Liquid fueled, it burns kerosene and liquid oxygen.

Because of weight and bulk, the propellants have the first stage to themselves, except for the engine, two helium spheres, and an H_2O_2 tank. To withstand acceleration against the force of gravity, structure of impressive strength is required. For these reasons this stage of the Vanguard accounts for more than three-fourths of the total take-off weight.

Steam-turbine fuel pump

The engine incorporates a turbo-pump, which delivers the propellants from the tanks into the thrust chamber and also drives the hydraulic pump for the control system. Power for the turbo-pump is derived from high-temperature steam, which is provided by the decomposition of concentrated (90 per cent) hydrogen peroxide as it passes through a silver-screen catalyst chamber. This same steam, after being exhausted from the turbine, is ducted outboard to two small swivelling jet nozzles which normally point aft, but are capable of being rotated 45 degrees in a vertical plane to provide roll control.

Helium pressurization is used for several different purposes: 1, to actuate peroxide flow through catalyst chamber and turbo-pump; 2, to pressurize gas space above liquids in fuel and oxidizer tanks; 3, to pneumatically actuate roll jets and propulsion-system valves; and 4, in the crucial few seconds at burn-out and during first-stage separation, to augment deteriorating turbo-pump exhaust as working medium for roll jets. The helium is originally stored at about 4400 psig.

Brains of the entire vehicle are in the second stage, directing the entire flight from take-off to orientation on the path in which the little ball circles the earth. A three-dimensional reference system of gyroscopes has been built by Minneapolis-Honeywell. Measuring constantly the roll, pitch and yaw of the vehicle, it furnishes the necessary information to the automatic pilot built by Vickers Electronic, a part of Sperry-Rand.

Auto-pilot in turn is responsible for keeping the entire unit on a predetermined course and schedule.

Sharing the middle portion of the Vanguard with the brain is another rocket motor, shown in Fig. 3, built by Aerojet-General Corp. This engine is fueled by white fuming nitric acid and unsymmetrical dimethyl-hydrazine, a hypergolic mixture reacting violently on the slightest contact. Like the first-stage rocket, its thrust chamber is gimballed, taking instructions from the Vickers pilot to guide the satellite launcher in its path.

Third stage of the Vanguard is actually contained in the second until high in the flight. The second stage contains mechanism to detach the nose cone, impart spin to the last stage, and retard itself as the last stage and the satellite emerge.

Rocket for the third stage is fueled by solid propellants, and is built by Grand Central Rocket Co. No provision is made for steering this portion of the vehicle, for once it is separated from the intelligence of the middle stage, it is in the proper path, and its only function is to impart the necessary velocity to the satellite.

Separation of the satellite is accomplished by a device invented for that specific purpose, which also gives the ball a relative movement away from its launcher of about 3 fps. It is triggered by the surcease of acceleration after burnout, pausing 26 seconds before pushing the two apart.

A Typical Vanguard Flight

Ready for take-off on a typical trip, the Vanguard stands 72 ft high at Cape Canaveral, Florida, weighs 22,600 lb. On 27,000 lb of thrust from its first engine, it rises vertically, in ten seconds begins to curve toward the southeast. Acceleration is tremendous at this point, for when it begins to curve it is moving only 90 fps, but before the store of fuel is gone, it is roaring forward at 6075 fps, better than a mile each second. As its fuel is rapidly depleted, it loses a large percentage of its weight.

Traveling at this speed, 33 miles above the earth, 142 sec after take-off, the first stage has contributed well over half of the total energy required. Burned out, it is rejected by the programmer in the second stage. Explosive bolts effect the separation.

Remainder of the vehicle weighs 4800 lb as the second rocket motor takes over. Only part of this portion of the flight is powered, burnout occurring in slightly less than two minutes, 122 miles above the Atlantic. Speed here is over 14,700 fps. About half-way through this powered period, the nose cone is cast away, leaving the satellite exposed to the now-tenuous atmosphere. Streamlining, at this height, means little.

Coasting upward to a height of 261 miles, the high intelligence of the second stage is performing the critical task of orientation. Guidance here is obtained by the expulsion of helium, which is used to pressurize the pro-

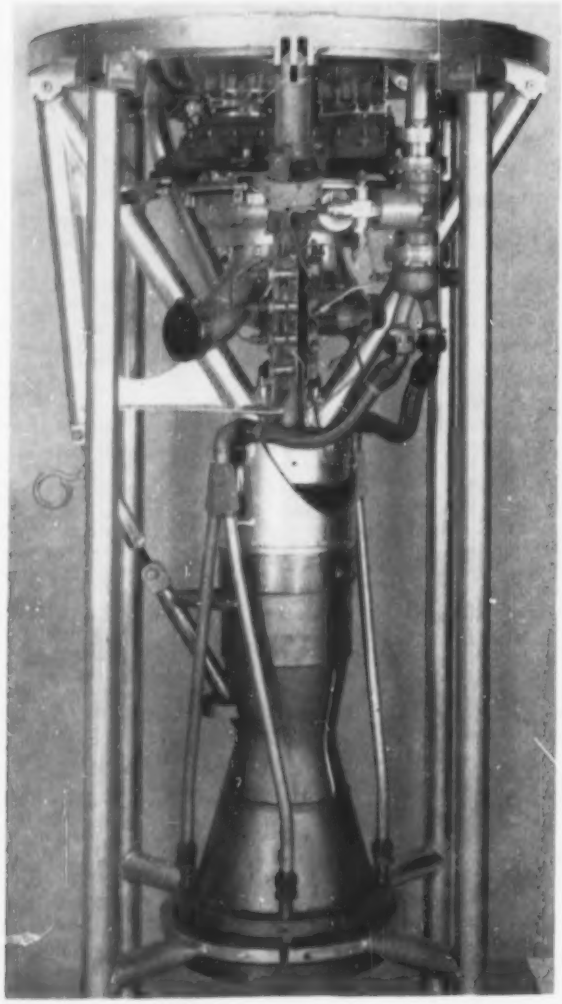


Fig. 2. First-stage engine burns kerosene and liquid oxygen

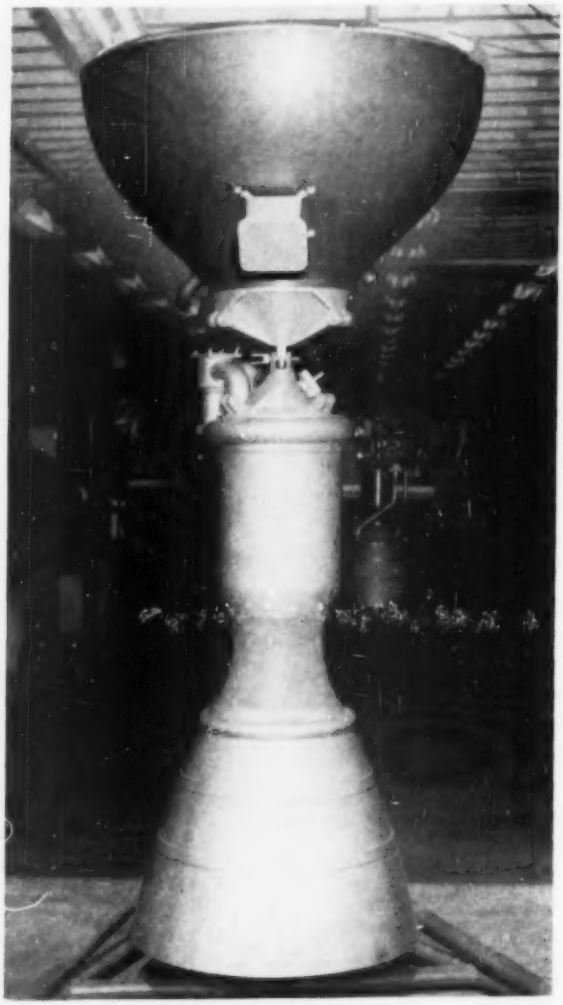


Fig. 3. Hypergolic propellants insure second-stage ignition

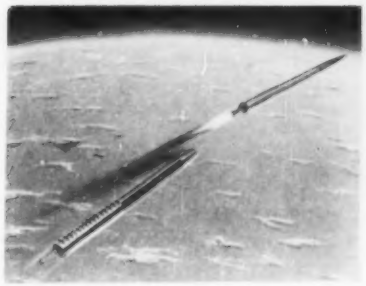


Fig. 4. Its job done, first stage separates, hits ocean 251 miles from start

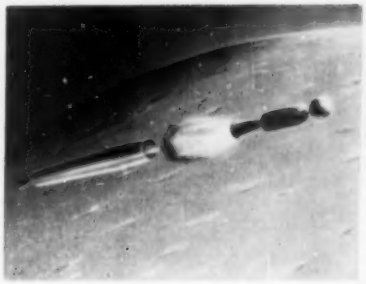


Fig. 5. Die is cast. Height, direction exact, third stage seeks orbital speed

Courtesy of The Martin Company

Fig. 6. Bon voyage, little one. Lonely monitor begins a long, one-way journey

pellants in both stages. Separation of the stages must occur at nearly level flight, in the predetermined direction, and at the right altitude.

At the proper time, moving some 14,000 fps, the separation sequence occurs. A rocket-powered turntable revolves, spinning the third stage of the vehicle and the satellite at about 150 rpm. The larger unit is slowed by small rockets, and as it decelerates, the other rocket and its passenger coast out of it. Suddenly its power plant is ignited, and in the next few seconds its speed nearly doubles, increasing to over 26,000 fps.

Then, less than ten minutes after take-off, above a point some 864 miles away, the satellite is freed. It begins its monitoring of near-space, circling the earth every 90 minutes. The exact dimensions of its elliptic orbit won't be known until the flight is measured by waiting instruments. Its parameters depend entirely on the amount of error in the launching, which is why the coasting flight of the second stage is so important. It is desired that the ball approach no closer to the earth than 200 miles at the closest point, and soar no further than 1500 miles at the farthest.

Sputnik I

Several things were revealed to thoughtful Americans when Sputnik I assumed its nearly-circular orbit October 4. That this launching was an excellent one from a control standpoint is obvious — the satellite was placed in its polar orbit at tremendous height with unerring precision. Credit for this must certainly be given, for the variables are far too great for luck to play an important part. Each and every part of the control mechanism, as well as the rocket itself, functioned with utmost reliability.

Science of rocket fuels is still in its infancy, but the Sputniks indicate the Russians may be farther along than we are. If reports that their original vehicle weighed 60 tons at take-off are true, their ratio of starting weight to payload was about 650 to one. The best we have been able to attain with the Vanguard is about 1000 to one — and Sputnik went considerably higher, and assumed a more difficult orbit. That this remarkable ratio, if true, represents propellant improvements is attested by the fact that the starting weight of the Vanguard is almost 90 per cent propellant, which means that this is the only place such significant cuts could be made.

Best estimates of the first thrust of the Russian launching vehicle center around 200,000 lb. Our Atlas missile engine is reputed to develop a thrust of 150,000 lb. Vanguard, as reported above, develops 27,000 lb.

Hundreds of fuels exist on paper only, which, if they could be brought into physical existence and stored in reasonable fashion, would give our rockets vastly improved performance. These fuels have higher energy content, both by volume and by weight, and generate huge volumes of gases upon combustion. With them, single stages could emerge from the atmosphere, escape gravity, and journey to distant planets. Research and development programs on these fuels are a large part of our top-priority, highly-classified missile work. Where we stand in the race we can only judge by demonstrated results.

Were it not for the grim implications, the pursuit of the mysterious frontiers hiding the secrets of free radicals and monopropellants would indeed be a romantic story.

Space Propulsion

There is some reason to expect that power systems for actual movement in space will pose fewer problems than the gravity-breaking propulsion systems. Since resistance to travel through space is slight, a very small thrust is required to accelerate vehicles to velocities of thousands of miles a minute. Almost no thrust is required to sustain this velocity — witness the flight of the satellites.

Sources of heat energy in space should not be a problem. Solar energy, concentrated by a parabolic reflector automatically aimed at the sun, could be used to heat a working fluid which would expand and exert the necessary thrust. A small source of atomic radiation could be used to accomplish the same purpose. Either would minimize the refueling problem, although the working medium, of course, would be exhaustible.

Another possibility is the use of the heat of an electric arc, but the generation of the electricity requires considerable fuel, and defeats its own purpose.

Also mentioned often as a space propulsion unit is the ion motor, in which ions are accelerated to high velocities and ejected from a tube in a direction opposite the desired acceleration. Technical difficulties indicate that this motor may be some years away. As we graduate from interplanetary to inter-stellar travel, however, this motor which burns so little fuel may become a necessity.

Eventuality, too, is the photon rocket, in which reaction to the energy of light is the propelling force.

Requirements for Power

Power systems for controls, communication and domestic services will probably obtain their generation from turbines catching part of the exhaust stream. This principle is now in successful operation on the rocket engine of the Navy's surface-to-air Lark missile. From the generators must come electrical energy sufficient to operate all of the controls of the vehicle; to communicate across the vast volumes of space; to condition the air for repeated human consumption, and heat and cool it as necessary; to provide lighting in the vehicle, and put juice through powerful landing lights when necessary; and to provide for the myriad of domestic services such as cooking. There will undoubtedly be other needs for power that we do not foresee at the present time.

But it is hard to realize that all this is not in the distant future — that many of us may see it in our lifetimes. Little Sputnik and October 4, 1957, are destined to become as important to future generations as Columbus and October 12, 1492, are to ours. The power engineer of the future may well find his duties on a giant landing-and-launching platform circling the earth at a height of 600 to 1000 miles, a man-made satellite actually constructed in space, and containing all the facilities of a leading airport. When this is a reality, perhaps man's viewpoint will be broadened, and he will realize how insignificant his differences with his neighbors really are. THE END

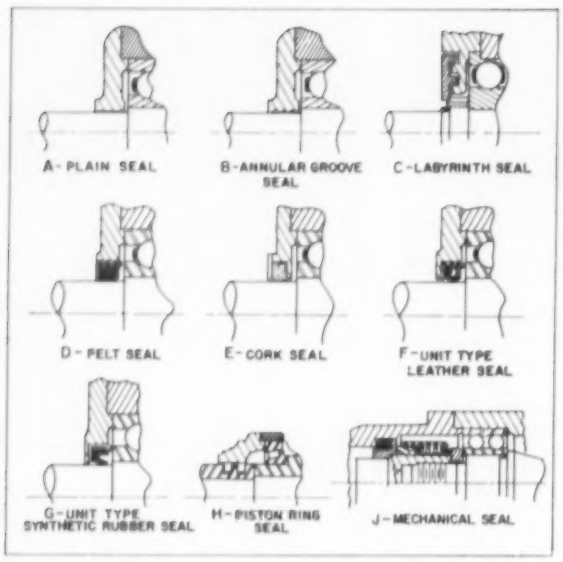


Fig. 1. Forms of clearance and contact seals used with ball and roller bearings. Table below shows characteristics

Correct Practice for Oil and Grease Seals

To do a good job, any ball and roller bearing seal must, 1, retain lubricant in the bearing, 2, prevent dirt from entering. Selection of the right seal is all-important. So is knowledge of slingers, shrouds and other supplementary parts designed to help primary bearings do their job even better. This article covers the know-how you need

BY E. P. STAHL *

FIGURE 1 shows various forms of clearance and contact seals used with ball and roller bearings. There are plain seals, grease groove seals, labyrinth seals, felt seals, cork seals, unit or lip-type leather seals, unit or lip-type synthetic rubber seals, and piston ring seals — all used for sealing lubricant in bearings and excluding extraneous matter from them.

A, B and C in Fig. 1 are not true seals as they depend upon the lubricant (grease) between the rotating and stationary members to do the sealing.

D in Fig. 1 shows a self-contained felt seal used to protect a ball or roller bearing from dust and dirt.

E is a cross-sectional drawing of a cork seal held in a seal recess with a retainer or cover plate. These seals are used for applications where there is moisture or water present in the seal area.

F and G are sectional drawings of spring-loaded leather and synthetic unit or lip-type seals used extensively in motor cars, tractors and general industrial machinery. These seals, like the felt seal, D, are designed for a press-fit into a machined housing bore or seal recess.

H in Fig. 1 is a sectional drawing of a piston ring seal used for high temperature applications where some leakage can be tolerated.

Figure 1-J shows the application of a mechanical seal to a double-row ball bearing in a pump.

Type of Seal	Relative Sealing Efficiency	Limiting Speeds	Relative Friction	Space Required	Difficulty in Assembly	Lubrication Required	Wear	Relative Cost	Remarks
Plain	Poor to Fair	None	None	Little	None	None	None	Very Low	Does not hold oil or any pressure. Not effective against dirt or moisture.
Annular Groove	Poor to Fair	None	None	Little	None	None	None	Low	Does not hold oil or any pressure. Not effective against dirt or moisture.
Labyrinth	Fair to Good	None	None	Moderate	Moderate	None	None	Moderate	Does not hold oil or any pressure. Must fill with grease to keep out dirt.
Felt	Fair to Good	Moderate	Low	Little	Little	Little	Little	Low	Does not hold oil under pressure. Not effective against excessive dirt or moisture.
Cork	Fair to Good	Moderate	Low	Little	Little	Little	Little	Moderate	Does not hold oil under pressure. Resists liquid or gas penetration. Not affected by temperature variations.
Unit Type Leather	Good	Moderate	High	Moderate	Special Tools Req'd.	Plentiful	High at High Speeds	Moderate	Seals only in one direction. Will wear rapidly if allowed to run dry. Needs smooth shaft surface.
Unit Type Synthetic Rubber	Good	Moderate	Moderate	Moderate	Special Tools Req'd.	Plentiful	High at High Speeds	Moderate	Seals only in one direction. Will wear rapidly if allowed to run dry. Needs smooth shaft surface.
Piston Ring	Good	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Will withstand high temperature. Will carry low pressure.
Mechanical	Very Good	Moderate	Low	Large	Moderate	Moderate	Moderate	Relatively High	Designed to seal in one or two directions. Takes pressure and lateral movement.

This table shows how the characteristics of the 9 seals in Fig. 1 differ

Synthetic Rubber Seals

Figure 2 shows drawings of spring-loaded synthetic rubber unit or lip-type seals designed to press-fit into a machined bore or seal recess. The sealing lips are held in contact with the shaft by means of either a finger- or garter-spring. Figure 2-A utilizes a finger-spring; B, C and D utilize garter-springs.

The popular methods of mounting unit or lip-type seals are shown in Fig. 3, A, B, C, and D.

Where sealing conditions are not severe and a spring-loaded seal is not needed, springless seals, as shown in Fig. 4, A, B, and C, may be used advantageously. Figure 4-A shows a

*Product Engineering Dept., Garlock Packing Co

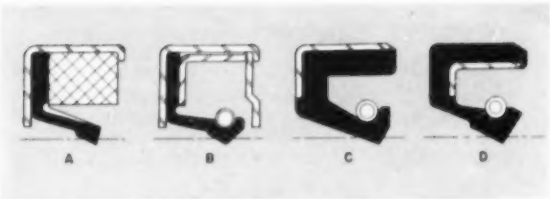


Fig. 2. Unit-type spring-loaded seals used for machined bore

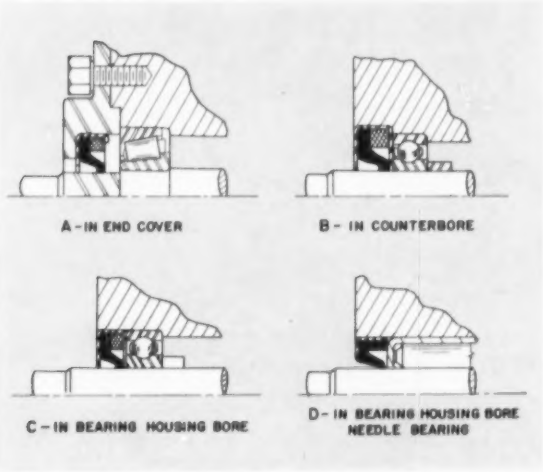


Fig. 3. Popular ways of applying unit-type seals to bearings

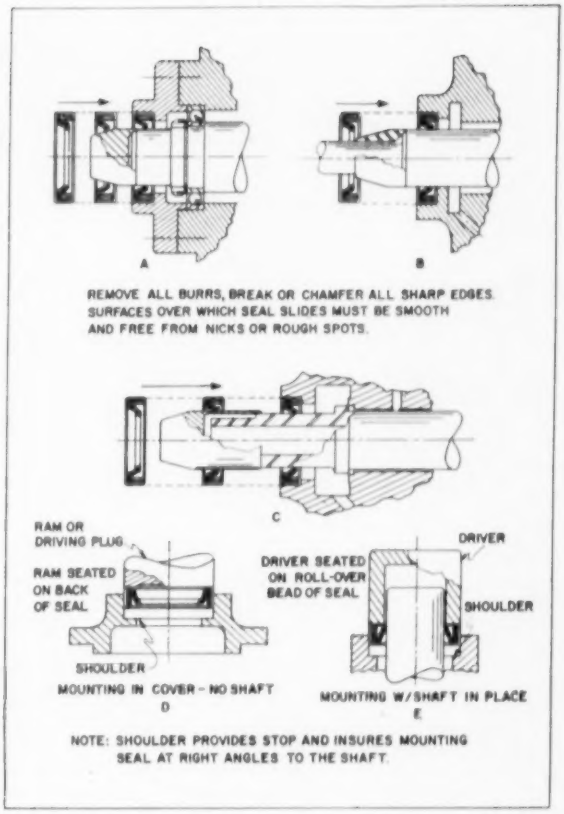

A
B
REMOVE ALL BURRS, BREAK OR CHAMFER ALL SHARP EDGES. SURFACES OVER WHICH SEAL SLIDES MUST BE SMOOTH AND FREE FROM NICKS OR ROUGH SPOTS.
C
RAM OR DRIVING PLUG
RAM SEATED ON BACK OF SEAL
SHOULDER
MOUNTING IN COVER - NO SHAFT
D
DRIVER
DRIVER SEATED ON ROLL-OVER BEAD OF SEAL
SHOULDER
MOUNTING W/SHAFT IN PLACE
E
NOTE: SHOULDER PROVIDES STOP AND INSURES MOUNTING SEAL AT RIGHT ANGLES TO THE SHAFT.

Fig. 5. Five types of tools used for installation of seals: cone or bullet A, tapered sleeve B, sleeve C, ram D, driver E

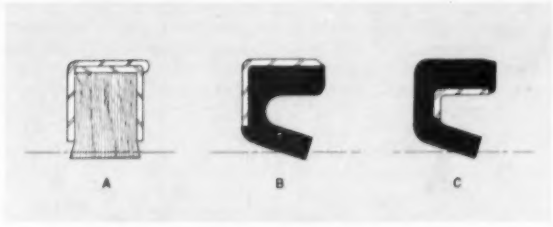


Fig. 4. Springless seals are often used for simple sealing

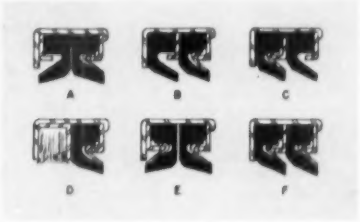


Fig. 6. Single unit seals are available in combination

large unit-type felt seal designed for a press-fit in a housing bore. The rest of the designs shown in Fig. 4 have synthetic rubber sealing members bonded to a metal shell or stiffener ring. Although not as effective as spring-loaded seals, these springless seals are often used where simple sealing problems are encountered and cost is a factor.

Combination Seals

The single unit or lip-type seals are also available in combination or dual constructions consisting of two sealing members mounted in a single case, as shown in Fig. 6, to meet unusual operational or environmental sealing problems. All the combination and dual seals illustrated in Fig. 6 are designed to be press-fitted into a counterbore or recess in the housing bore in the same manner as for the single unit or lip-type seals described above.

Points on Installation

Every precaution should be taken to keep dirt out of seals prior to and during installation. Seals should be kept in their original wrappers or cartons until they are ready to be installed. Any grit or dirt they pick up may imbed in the sealing member and impair its sealing efficiency. Dirt that clings to a sealing member of a seal may also get into the bearing and greatly shorten its life expectancy.

Oil and grease seals fail for various reasons. Among these are hardened and gummed grease, weakened spring tension, damaged sealing members, and metal parts bent out of position. Gummy or hardened grease can be removed with solvent.

As is the case with bearings, a good many seal failures are caused by improper installation. The following suggestions are offered on proper seal installation:

1. The sealing member of an oil or grease seal should be lubricated prior to installation, by applying grease or oil. This facilitates assembly and prevents the seal from burning up in the first few minutes of operation.

2. Shafts or hubs over which the seals are installed and upon which they operate should be smooth (5–20 micro in.) to insure leak-proof contact. Remove all burrs or sharp edges from the shaft.

To install a unit or lip-type seal

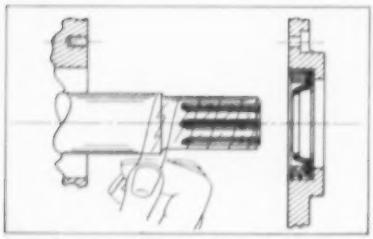


Fig. 7. Cellulose tape wrapped around shaft protects sealing lip from damage

over a shaft, proper installation tools should be used. These are five types of tools used for this purpose: a cone or bullet as shown in Fig. 5-A, a tapered sleeve or collar as shown in Fig. 5-B, a sleeve as shown in Fig. 5-C, a ram as shown in Fig. 5-D, and a driver as shown in the E drawing of Fig. 5.

When using the cone shown in Fig. 5-A, place the large end against the squared end of the shaft with the wiping edge of the seal towards the lubricant until it drops on the shaft. This method of installation will keep the wiping edge of the seal from being damaged.

To install a unit or lip-type seal over a shaft having splines, keyways or holes in it, use a thimble or thin sleeve as shown in Fig. 5-C. If assembly tools are not available, use a piece of 0.010-in. shim stock made from steel or brass, and made cone-shaped.

For emergency or field installations where a seal must pass over splines, keyways or holes, a piece of cellulose (Scotch) tape can be wrapped around the shaft, as shown in Fig. 7, to protect the sealing lip from damage.

Always bear in mind that the smallest nick or scratch on the lip of a seal can cause a big leak. For this reason, it is vital that all mounting tools and shaft contact surfaces over which the seal passes be free of burrs or other imperfections which might damage sealing lips.

The next important items in the seal installation program are the ram or driving plug and the driver shown in Fig. 5-D and E. The pilot of the ram or driver should be slightly smaller in diameter than the counterbore in which the seal is placed. In addition, the inside diameter of the ram or driver should be such that no pressure is exerted on the sealing face when the seal is installed. If this precaution is not taken, the inner parts of the seal may become jammed, and cause the seal to become damaged beyond repair.

When a unit or lip-type seal must operate on a portion of a shaft over which a roller or ball bearing has been pressed, as shown in Fig. 8, every precaution must be taken to smooth the shaft with fine emery or crocus cloth before the seal is installed, to remove rough spots and nicks from the shaft.

Large Unit or Lip-Type Seals

Although the big demand is for unit or lip-type seals in the small- and medium-size range, there is also a demand for large unit or lip-type seals shown in Fig. 9-A and B, for use in steel mill equipment, cranes and other large machinery. Figure 9-A shows a sectional view of a large synthetic rubber sealing member and a garter-spring. In this design the garter-spring is supported in a metal carrier near the tip of the seal, where it does the most good.

The seal shown in Fig. 9-B is equipped with a bonded-in finger-spring. This seal is available in both the solid and split or cut-open types. Instead of being slid over the shaft, as is the case with the solid or continuous seal, the split seal is opened up, wrapped around the shaft and inserted in the seal recess. Both the solid and the split types are held in place with a retainer or cover plate. This seal minimizes costs and reduces machine downtime.

Large seals are playing an important role where continuity of operation and increased production are important. When mounting large seals on very large shafts, such as steel mill roll necks and heavy industrial equipment, it is essential to remove all sharp edges on the shaft and other parts over which the seal must pass. Before the seal is applied, the housing or recess bore should be cleaned and lubricant applied to all surfaces. The seal should then be seated by starting it squarely in the seal recess.

Tolerances on the outside diameter of the metal cases of large unit or lip-type seals are held to plus or minus 0.002-in. To insure proper press-fit in the housing or recess bore, the nominal outside diameter of the metal case is made larger than the nominal diameter of the bore.

A thin coating of shellac or gasket cement may be applied to the inside of the housing recess or to the outside of the seal shell as an added precaution against seepage between those two metal surfaces. If such materials are used, however, care must be taken to make certain that none is spilled on the shaft or sealing member. A coating of heavy grease or tallow is helpful in seating seals of large diameter.

For unusually large seals, it may be advisable for two men to tap simultaneously at diametrically opposite points, driving against blocks of wood to protect the seal from direct hammer blows.

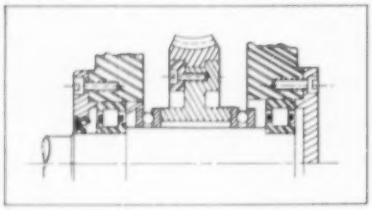


Fig. 8. Be sure to remove rough spots from shaft in worm gear shaft mounting

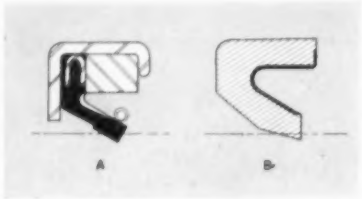


Fig. 9. Large unit or lip-type seals are used in cranes, other heavy units

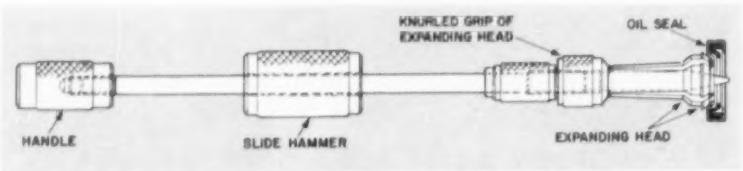


Fig. 10. Using this oil seal puller facilitates unit or lip-type seal removal. Expanding head is enlarged by rotating handle, and the slide hammer is reciprocated

Removal Technique

In addition to the question of how to install the seal, the user usually wants to know how to remove seals once they have been installed.

Some maintenance men remove seals from a housing with a cold chisel, others fasten small screws to the back of the seal case so that they can pull squarely on the seal; but neither of these methods is entirely satisfactory.

An oil seal puller, as shown in Fig. 10, is now available, which facilitates removing unit or lip-type seals with metal shells from housings. With this tool the expanding head is enlarged by rotating the handle, and the slide hammer is reciprocated.

If a seal is properly selected for the job it has to do and the above precautions are strictly adhered to, the seal should give a full measure of service. THE END

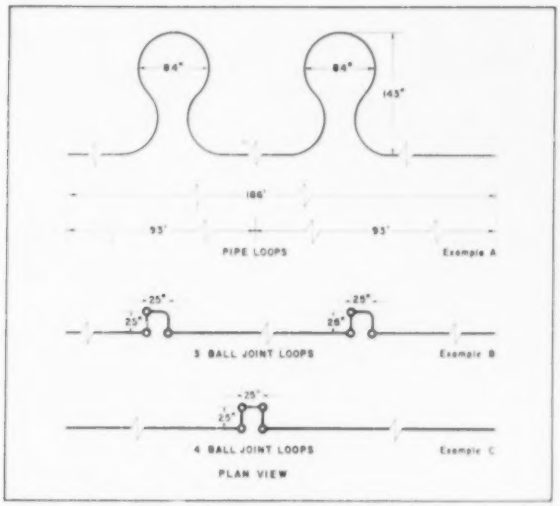


Fig. 1. Diagram showing long pipe run carrying steam at 600 F. Expansion in this 6-in., Schedule 40 steel pipe is 9 inches; it can be handled effectively with ball-joints as shown

Fig. 2. Outdoor installation of ball-joints allows for expansion in a 200 foot length of 4-in. pipe, which carries 150-psi steam. (Kalamazoo Paper Co, Kalamazoo, Michigan)

New Space-Saving Expansion Loops Made With Ball Joint Fittings

EXTENSIVE piping layouts present problems resulting from expansion and anchoring of the pipe. Allowance must be made for this movement, and to prevent damage to connected equipment. Standard design procedure has called for pipe loops, or U-Bends, to compensate for expansion; or the installation of special expansion type fittings, connected directly into the pipe line.

Now a new method has come to light which involves the use of standard ball-joint pipe fittings, and which offers some excellent space-saving solutions. In many cases, the pipe anchors can be eliminated in this method, also. Piping in close quarters and around equipment presents design problems which may be quite expensive to solve. Many of these can be effectively settled by the installation of two, or more ball-joints.

A graphic illustration of close-quarter expansion "loops" is shown in Fig. 1, together with a comparison of conventional pipe loops. This example covers two good solutions to 9 inches of expansion in a 186 ft run of 6 in. Schedule 40 steel pipe, at 600 F. Conventional design might call for two U-bends as shown in example A; the same movement can be handled by two loops, each with three ball-joints, as shown in Example B. Greatest possible savings in space can be gained by the installation of four ball-joints, as shown in Example C.

Additional savings in space can be effected in those installations where changes in direction occur in the pipe runs. In such cases, the ball-joints can be used to replace pipe elbows, and might also be a solution to conflicts with other piping. This is especially true in pipe tunnels, and in equipment connections, where space is at a premium.

Even where space is not necessarily a critical factor, the use of ball-joints will often save considerable cost in an installation; Fig. 2 shows an outdoor expansion joint made of two ball-joints. Note the absence of extra supports for a pipe loop; this item accounts for quite a bit of the total expense of conventional pipe loops.

Comparison Based on Total Costs

Cost comparisons of conventional and ball-joint expansion loops must take into account all factors of the installation. This includes material, labor, hangers, supports, and insulation; and, if additional structure is required for housing the loop, it too must be included. Power engineers have reported considerable savings, in many installations of ball-joint expansion loops; some in first cost only, and others in overall operating costs. As mentioned, if the ball-joint serves as an elbow in the piping layout, the cost picture is even more interesting.

An excellent application of the use of ball-joints, in solving a tricky expansion problem, is that of a long steam header, with a sizable number of equipment lines connected to the header. For example, a header carrying 150 psi saturated steam at about 375 F might have many take-off lines to heated process equipment. The expansion in this header would be about 3.9 inches; this is more movement than rigid pipe and fittings can absorb, especially in close connections. In such a hook-up, three ball-joints in each take-off line will provide a means of absorbing the expansion, and will be maintenance-free.

In those applications involving temporary piping connections to equipment, either in use or on test, ball-joints provide an economical means of providing for expansion, close-coupling, and ease of connecting and disconnecting. If the temporary equipment is heavy or complex, ball-joints will facilitate the connecting, and save time by eliminating accurate cutting and fitting of pipe lines.

Many ingenious applications of ball-joints have been reported by power engineers; in addition to those mentioned, there is the method of using special gaskets for breaking the continuity of underground lines, to prevent electrolysis. In such an installation, a couple of ball-joints with special gaskets will simultaneously solve the problems of expansion, settlement stress, and electrolysis. Various materials used in the ball-joints provide solutions to many tough problems; for example, a stainless steel fitting with special high-temperature gaskets, handles a 1000-F piping installation with complete safety. Special composition gaskets are available for unusual applications.

For more information write the Editor, or jot Ball-Joint Expansion Loops on the inquiry card enclosed in this issue. THE END

Fig. 1. Within 10 minutes the entire system had failed and the metal-clad switchgear house was on fire with 30-ft flames

When Fire Strikes a Power Station

How the municipal power plant at Springfield, Illinois, coped with a serious shutdown and complete failure of electric and water systems. Cause was a sudden and spectacular fire which started in the switchgear house because of faulty relay operation

BY F. H. WILCOXON*

AT 11:39 O'CLOCK on the night of Friday, September 14, 1956, a major disturbance occurred at Springfield's Lakeside Power Station. This put four of the five 23-kv main power buses out of service, leaving only one transmission line and one 20-mw generator in service.

Within 10 minutes the entire system had failed and the metal-clad switchgear was on fire. Before the fire department arrived on the scene, flames were shooting from the roof of the switchgear house 30 ft into the air. What had happened?

The initial disturbance, probably set up by a lightning surge on the power lines, was due to the failure of the current transformer on the 1–4 bus tie. The resulting arc was caused by faulty operation of the relays, and burned a 4-in. hole through the metal compartment. This heated the petrolatum in the compartment to flash temperature and ignited it.

Located directly above the flame was an oil-filled transfer switch, which overflowed hot oil onto the rapidly spreading flames. Next, the oil-filled potential transformers located on top of the switchgear exploded, blowing holes in the roof. This added air and hot oil to the flames, which now enveloped the bus structure completely.

The structure contained twelve 600-amp, 23-kv oil circuit breakers which were connected to three 23-kv buses. The main bus and current transformers were enclosed with 10-gage metal and filled with petrolatum. The oil circuit breakers, potential transformers, and transfer switches were oil-filled. Fortunately the main power transformers were located outside of the structure and were not damaged by the fire.

Fighting the Fire

During the fire fighting, the only equipment inside the power plant that could be operated was a turbine-driven city water pump, a boiler feedwater pump, and a gasoline engine-driven fuel oil pump. The lighting torches were kept burning in the hot boilers. Feedwater could be pumped as needed. These boilers supplied enough steam to keep the turbine-driven city water pump running, which, with the help of the overhead 1,000,000-gal. tank, supplied water to the system during the shutdown at considerably reduced pressure.

While fighting the fire, an attempt was made to get one of the turbine generators, which had a steam-driven circulating water pump, up to speed. This was not possible due to internal rubbing, and steam was being used which was badly needed to run the city water pump for supplying water to the fire fighters.

It was not possible to use the interconnection with the Central Illinois Light Company, to supply standby emergency power, because it was connected to the bus that was on fire.

*Supt., Electric Production, Dept of Water, Light & Power, City of Springfield, Illinois

The only other supply available was through the interconnection with the REA system. This system is also connected to the Illinois Power Company through a normally open switch. This was very uncertain as a source of emergency power due to long transmission distance and other limiting factors, but it was decided to try this connection, as any other hookup would cause a much longer delay.

After two or three hours of patrolling the lines, opening circuits to substation on the transmission lines, and installing jumpers at fuses, power was finally fed to the Lakeside Plant bus. It was fortunate that the REA load was at a minimum, because the bus voltage was only about 2200 v at Lakeside Plant, which is normally 2400 v. It was now possible to get the lights on at the plant and start the auxiliaries. The fans on one of the hot boilers were started, but the mills would not start. The voltage on the auxiliary bus would drop to 1500 v and the mill motor breaker would trip out.

It was then decided to try the other hot boiler, which had the mills equipped with Rawson centrifugal-type couplings. This reduced the inrush current so the mill came up to speed, and a coal fire was lit off in this boiler.

As soon as the steam pressure had recovered sufficiently, the steam-driven city water pump was primed and put back in service. It had shortly before lost its prime due to loss of speed caused by low steam pressure. It was then possible to get the water pressure restored for supplying city water to our auxiliaries as well as to the rest of the system.

Power Again

One of the two usable turbine-generator units was next started rolling and warming up. At 4:30 A.M. Saturday, September 15, this unit was synchronized back on the Lakeside Plant bus. Shortly thereafter, or as soon as the necessary switching could be accomplished, about 75 per cent of the electric system was energized. In order to pick up the remainder of the load, it was necessary to cut the interconnection cables loose from the damaged switchgear bus and splice them to one of the transmission lines. The Central Illinois Light Co was then able to energize the rest of the transmission system at 2:30 P.M. Saturday afternoon.

Thus ended the longest interruption of service ever experienced at Lakeside Plant.

The consulting engineers, Burns and McDonnell of Kansas City, Mo., were ably represented during the emergency by A. F. Hartung and William Rumans. They gave valuable technical assistance to city engineers and personally planned and supervised the installation of temporary lines and circuits. This work involved quickly installing overhead lines, fuses, disconnect switches, much temporary wiring, and — lacking in proper relay protection — flexibility of operation, and code conformity.

Problem of Reconstruction

It was now necessary to obtain new electrical equipment quickly, also cable and other supplies, and begin the extensive rewiring and reconditioning of all salvageable equipment damaged by the fire. This was urgent because four transmission lines were operating on only two oil circuit breakers. Only three of the five generators could be used, since we did not have usable oil circuit breakers.

The city was fortunate in locating two 1200-amp, 34.5-kv oil circuit breakers which could be purchased and were ready for early shipment. These were ordered by special emergency action of the City Council.

The interconnection to Central Illinois Light Company was connected to one of the remaining 23-kv buses by a 34.5-kv oil circuit breaker being used to supply power to the No. 2 water works transformer. This transformer was then connected to the main bus and energized through fused disconnect switches.

After cleaning up the petrolatum and debris, and making temporary repairs to the switchgear house roof, inspection of the damaged switchgear was begun. Preliminary inspection and "highpotting" indicated that

Fig. 2. Temporary overhead lines and circuits had to be installed quickly

Fig. 3. After the fire was over, the switchgear house looked like this. Temporary repairs to the roof were made first

Fig. 4. Inside the gutted switchgear house. About half of the equipment was salvaged. Reconditioning was begun at once

Fig. 5. Petrolatum from bus and transformer compartments had to be removed by hand to prevent damage to bushings

Fig. 6. Electric water heater units were used to liquify petrolatum pumped back into the reconditioned compartments

about half of this equipment could be salvaged.

While the switchgear house was being rehabilitated and the equipment cleaned and repaired, another crew was busy erecting steel for an extension to the No. 4 bus section. When completed, this was to provide a permanent breaker position for turbine-generator unit No. 3, which was temporarily operating through the 1-4 bus tie breaker. Also to be connected to this extension by fused disconnect switches was station auxiliary transformer No. 3.

During this period, the two new oil circuit breakers arrived and were immediately installed on the foundations which were ready. These provided breakers to permit the separation of the four transmission lines to individual breakers.

Still urgently needed was another turbine generator and additional station auxiliary power, obtainable only by getting the damaged switchgear repaired. All available labor was being used to hurry this work to completion ahead of the fast approaching heavy winter peak load.

Fig. 7. Testing control panel before energizing the rebuilt switchgear house

It was necessary to remove the old petrolatum from the bus and current transformer compartments mainly by hand, to avoid damage to the insulation and ceramic bushings. The compartments and equipment were then thoroughly cleaned with solvent. The potential and current transformers were removed and sent to the Dowzer Electric Co at Mt. Vernon, Illinois, to be rewound and repaired. All old gaskets were removed, new gaskets made from sheet cork and installed with No. 3 Permatex. The oil circuit breakers were cleaned, rewired and filled with new oil.

Current transformer and bus compartments were then refilled with new petrolatum which was liquefied with immersion heaters and pumped into the metal enclosure. This petrolatum was carefully selected for its high flash point and dielectric strength. The bus was then "highpotted" at 45 kv and proved to be safe for continued use. The breakers, control wiring, relays, and all other equipment was installed and tested. All work was completed and the damaged bus returned to service December 2, 1956.

It was then possible to use the turbine-generator unit No. 2, 1-4 bus tie, auxiliary transformers No. 1 and 2, and return transmission line No. 4 to its permanent position. Turbine-generator unit No. 1 was delayed due to trouble in getting the potential transformers repaired.

Fortunately, during this reconstruction period no serious trouble developed that prevented the three usable boilers and turbine-generator units from operating, and no system outages occurred to cause interruption of service. Considerable work was deferred until labor and material were available, but this was work which did not affect the reliability of the system.

Preventing Another One

Plans to prevent a repetition of this disaster have been put into effect or are under serious consideration. All relays and control wiring pertaining to the reconditioned switchgear were checked and tested under the personal supervision of William Rumans, E.E. A simulated fault current was passed through the switchgear bus and cables with a 500-amp, a-c welder to see that the current relays would function properly.

Similar tests were made on buses 4 and 5 as soon as load conditions permitted. The consulting engineers have recommended that suitable testing equipment be purchased and a testing engineer assigned to check and service all relays periodically.

The present arrangement has reduced the kva capacity connected to the reconditioned switchgear. This is desirable since these breakers are rated at 600 amp, 23 kv, and only have an interrupting capacity of 500,000 kva. The oil circuit breakers on buses 4 and 5 are rated at 1200 amps, 34.5 kv and have an interrupting capacity of 1,000,000 kva. This should prevent future trouble as the reconditioned bus will not be subjected to fault currents exceeding the interrupting capacity of the circuit breakers.

Plans to firm up the standby power are being seriously considered. The city has since constructed a 69-kv transmission loop around the city. At various locations on this loop one or two interconnections with adjoining utilities are planned.

These connections will normally be open, but can be closed to pick up part or all of the electric load for the city in case of a partial or complete service interruption. The same reciprocal arrangement will apply for furnishing emergency power to the other utilities. THE END

New Two-Stage Free-Piston Engine

IMPORTANT breakthrough in the science of internal combustion, an advanced design of the free-piston engine has been announced by Baldwin-Lima-Hamilton Corp. The new power source appears to have high potential in many applications.

Free-piston engine produces pneumatic power, in contrast with the crankshaft engine which produces mechanical shaft power.

Therefore it is usually used in combination with a gas turbine, the hot exhaust gases expanding through and rotating the turbine blading.

New engine, possibly the most efficient user of fuel ever developed, and adaptable to burning a wide range of fuels, could replace other internal combustion engines in many areas.

Most promising immediate uses are for stationary and mobile power plants, railroad locomotives, marine power plants, tractor-trailer units and off-the-highway power-driven vehicles.

Two Types of Engines

Power output of the prototype design ranges from 125 shaft hp — available from a single gasifier — up to 1000 shaft hp when gasifiers are used in multiples. The range is available through the use of two types of free-piston engines.

Original, shown in Fig. 1, uses a single stage of compression and a patented movable compressor head to produce an output of 500 shaft horsepower. New design, in Fig. 2, produces 250 shaft hp with turbocharging; 125 shaft hp without turbocharging.

Feature of the new design is in its bounce cylinder. As in all free-piston engines, the diesel piston and the larger air piston are a single assembly, driven one way by the explosion in the combustion chamber, and bounced back by air pressure built up in the bounce cylinder. B-L-H puts this bounce cylinder inside the piston, as shown in Fig. 2, thus freeing both sides of the large piston for compressing scavenging air. Arrangement is simply made to use these two surfaces in sequence, making a two-stage compressor.

This advantage may be parlayed by supercharging the original inlet air, resulting in up to 60 per cent power output.

Analyses show that the engine combines the excellent power-to-weight ratio and torque characteristics of an open-cycle gas turbine (previously the best engine in these two respects) with the economy and efficiency of a diesel. It far surpasses the diesel in torque characteristics and power-to-weight ratio.

Multiple Units

By combining outputs of several gasifiers and feeding them into a common turbine inlet, individual units can be cut in to increase power, or cut off for economy during times of low power requirements. A gasifier can be serviced or overhauled while the turbine is running — by cutting it off from the turbine inlet line. This is possible with the turbine producing full power if the gasifier's output is replaced with that of a permanently-connected standby.

Because of their small size and light weight, the units can be handled easily without the use of heavy cranes and other bulky tools. Thus maintenance and replacement requires minimum labor and equipment.

Because of the inherent balance, the units are virtually vibrationless in operation and require only a minimum of foundation structure.

Majority of applications to which the free-piston engine could be applied immediately are now diesel-powered. The free-piston engine surpasses the diesel in these respects:

1. Has a much greater power-to-weight ratio — more power in a smaller size.
2. Burns a wider range of fuels.
3. Can be combined so that multiple gasifiers supply one turbine to provide a wide range of power outputs.
4. Provides high-starting torque, controlled variable speed and reversibility without using the more bulky and costly transmissions and torque converters.
5. Service and maintenance costs are expected to be less.

Engine is superior to the open-cycle gas turbine in these respects:

1. Consumes half as much fuel at full load; uses substantially less than half as much at low loads and at idling speed.
2. Decelerates much faster. (Requires no high-speed high-inertia compressor.)
3. Operates at temperatures of approximately 1000 degrees where ordinary steels can be used.
4. Provides immediate high-torque characteristics.
5. Gasifiers can be stacked or combined to supply one turbine and afford a wide range of horsepower output.

The pneumatic power from gasifiers can also be used directly. Steam plant efficiency can be increased through the use of gasifiers to pressure-feed pre-heated air to the boiler combustion chamber. Auxiliary starting of aircraft turboprop and turbojet engines can be achieved by using pneumatic power from gasifiers. Gasifiers can be altered to serve as efficient air compressors. THE END

* *Editor's Note:* Details of the supercharged free-piston engine, such as discussed in this article, were described in an article on the subject by Executive Editor Chester R. Earle in the April, 1946, issue of *Power Plant Engineering*, now POWER ENGINEERING. Article also traced the early development of the free-piston engine in Europe, and described units used on German and Japanese vessels during World War II. Free-piston gasifiers now power Liberty ship *Wm. Patterson*, which recently completed trial runs.

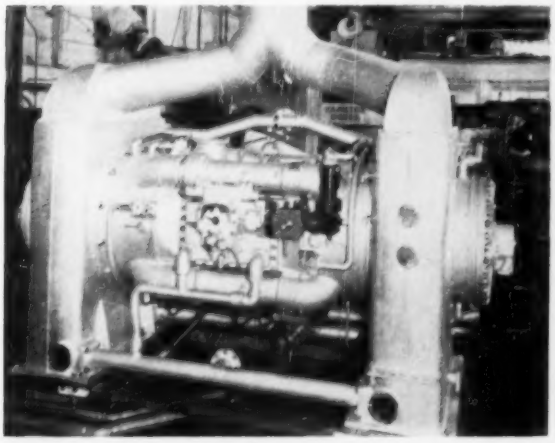


Fig. 1. Hamilton model DL single-stage gasifier on test block

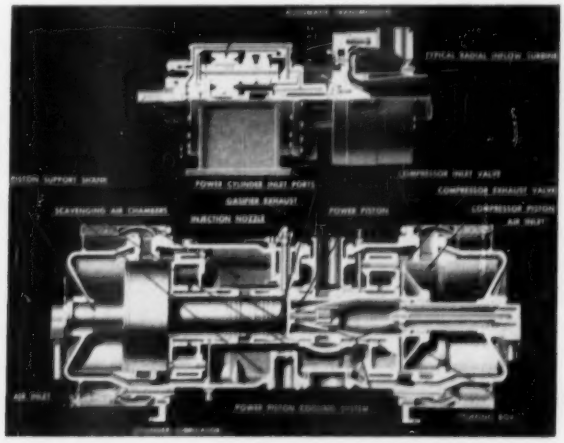


Fig. 2. Cutaway of new FP-165. Displacement varies with load

Are Your Cooling Towers Noisy?

They can be silenced, if necessary, by engineered equipment—which is expensive, but effective. Techniques of silencing are explained, by some basic information from the experts in the field

THERE WAS a time when noise from mechanical equipment was taken for granted, unless it reached a level where it became extremely irritating to the public. Then, good public-relations demanded that such noise be abated as much as was economically possible. Owners, designers, and manufacturers have become acutely aware of excessive noise generated by mechanical equipment. In a number of cases, nearby residents have taken drastic action to silence, or eliminate the offender; lawsuits have been won in many cases where the owners of extremely noisy equipment failed to provide silencing of their own accord.

As air conditioning has grown by leaps and bounds, it has created some unusual problems; especially in congested city areas where the cooling towers are located adjacent to hotels and apartment buildings. Noise from fans and dripping water can be particularly irritating to occupants of nearby buildings, and the courts recognize their rights to complain, and to seek relief.

Experts in this field point out that while the cost of silencing is necessarily high, it is considerably lower if incorporated into the original design. As the resonators, or sound-traps, are of large dimension, it may not be possible to add them to an existing cooling tower without a major revamp of the installation. It is quite important, then, for designers to consider the installation of silencers before the towers are installed.

Noise sources in cooling towers are both high- and low-frequency; they originate from fan air turbulence, vibration, motor, air intake and discharge, and dripping water. The vibration noises can originate from several sources, and be transmitted to the outside by mechanical connections, or go out air-borne. In most installations, the fan and motor will have been isolated from the building by proper absorbent mounting pads under the equipment. If this was not done in the original installation, it is certainly one of the more obvious steps which must be taken in noise abatement programs. Water piping and electrical conduits must also be isolated from the balance of the building piping by means of flexible connections.

Elimination of Air-Borne Noise

Air turbulence and dripping-water noises cannot be as simply eliminated as the strictly mechanical vibration elements, however. Attempts to muffle these noise sources, by purely mechanical means, might easily result in restrictions to air- and water-flow of such a magnitude as to decrease the efficiency of the cooling tower.

Experts in this field have proven that the only satisfactory means of squelching air-borne noises is to *confine them within the tower*. Simply stated, the solution to the problem is to construct a sound-proof enclosure around the tower, and install acoustical louvers for both air intake and air discharge. This is, of course, the general technique applied to any noise abatement problem; however, the solution to cooling tower noise control is made more complicated by the mere bulk of the equipment. Also, the one requisite factor of not placing restrictions on the flow of water and air within the tower.

Before any corrective design measures can be taken, it is essential that some bench mark be established, upon which to evaluate the correction required. If the project is one of silencing an existing tower, a measurement of the noise-level at the tower must be taken. Then, with the equipment shut down, the measurement should again be taken; this is called *ambient* noise level, by the experts. The difference between these two readings is the amount of correction required. This is largely academic, and is based on the premise that any correction below the prevailing noise level would not be justified, nor required by law.

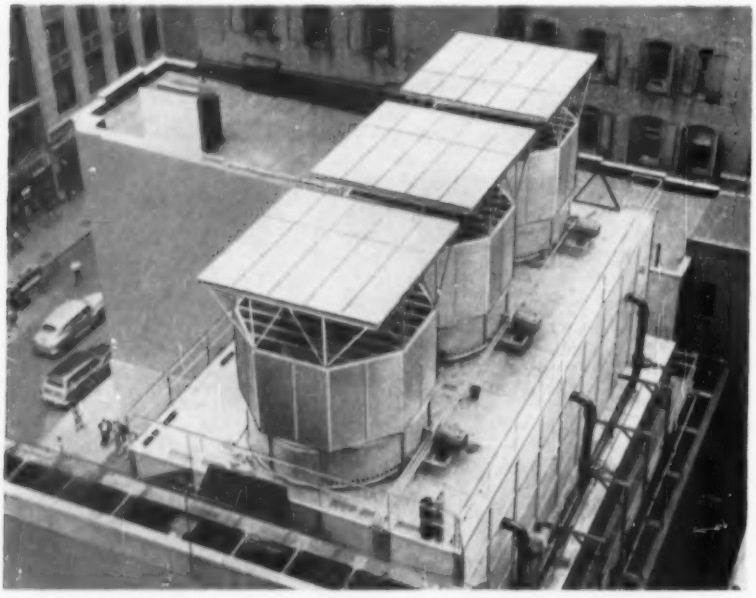


Fig. 1. Job-engineered cooling tower silencing installation. Air baffles, on intake, are at lower right. Special baffles silence the exhaust air current, on top of fan

Determination of Noise Levels

A Sound Level Meter is the instrument for measuring the noise level, before and after correction. The unit of sound measurement is the *decibel* (db); it is the accepted standard for measuring all commercial noises A microphone picks up the sound being tested, and the meter gives a reading of the sound pressure.

Since the human ear is very sensitive, and becomes accustomed to normal, everyday sounds, the measurement of *objectionable* noise must necessarily be referenced to the sound range acceptable to the ear. Research in this field has established the decibel rating of the various common commercial sounds and noises. Some of the more common ones are listed below, as a matter of general information:

Lowest normal hearing level	15 db
Average household sounds	35 "
Reasonably quiet offices	40 "
Average restaurant noises	57 "

General conversation	60 db
Noiseless typewriter	65 "
Average factory level	75 "
Printing press	80 "
Noisy factory level	90 "
Heavy street traffic	93 "
Comfortable noise limit	95–100 "

It can be noted that the lowest *normal* hearing level is 15 db, while the highest comfortable level is 100 db. Noise approaching the 120 db level can actually be painful, and continued exposure to 80–90 db noise can be harmful to the ear. (Modern industry has become very aware of these facts, and takes all possible measures to suppress objectionable noises.)

Having once established the correction required, the design of the enclosure and baffles can proceed. While the actual enclosure around the tower could be of properly-designed masonry construction, the weight loading on the roof structure would be prohibitive; consequently, such enclosures must be made of light weight materials, such as sheetmetal, asbestos cement board, or plastic. Walls of the enclosure usually consist of absorbent "sandwich" panels, made of solid sheets on the outside, perforated sheets inside, and sound-absorbing material between sheets. In the construction of these panels, care must be taken to design with corrosion-resistant materials, for obvious reasons. In some cases, it is not essential that complete enclosures be built around the entire cooling tower; however, some attenuation will be lost. It *is* essential that both intake and exhaust areas of the tower be acoustically treated, in all cases.

Expert Martin Hirschorn, of Industrial Acoustics Company, Inc, states that resonators (or acoustic filters) are required to properly muffle the low-frequency noise; the absorbent acoustic material is satisfactory for the higher frequencies. Such resonators as the Helmholtz variety are simply "sound-traps," or voids, in the walls of the enclosure, wherein sound loses its energy by being trapped inside the voids. Such designs have been worked out by the specialists in this field, based on scientific principles. In practical operation, however, the sound-control baffles are relatively simple.

One manufacturer, the Koppers Company, Inc, produces modular sound-absorbing panels, known as "Soundmetal," which have been engineered to produce satisfactory attenuation, or sound-muffling, in all frequency ranges from 128 to 4096 cps. With such modular panels, and adequate engineering service, the owner of an offending cooling tower can install the silencing equipment best suited to his particular problem.

On *new* installations, there will be no noise design criteria, based on operating conditions in actual use; in such cases, noise-level tests can be run by the tower manufacturer, before the tower is delivered. Using this data, proper designs of acoustical treatment can be prepared. As stated earlier, silencing design can be easily incorporated into the original installation; later addition of noise-abatement equipment might be difficult, or even impossible, to install. Due to the present day noise-consciousness of the general public, power engineers should add the item of cooling tower silencing to their list of items of building mechanical equipment. In silencing of towers, care must be taken to see that baffles are as maintenance-free as possible. (Photos courtesy of Koppers Co, Inc, and Industrial Acoustics Co, Inc.) THE END

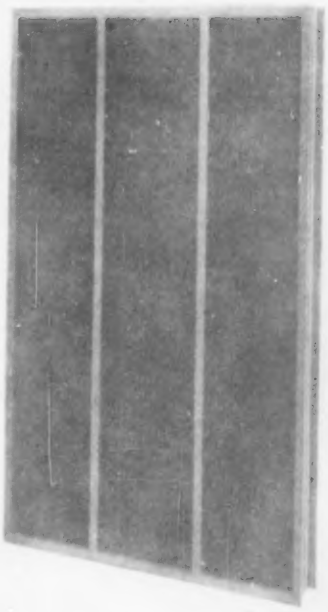


Fig. 3. Modular acoustic panel, consisting of metal back, sound-absorbing insulation, and perforated inside panel

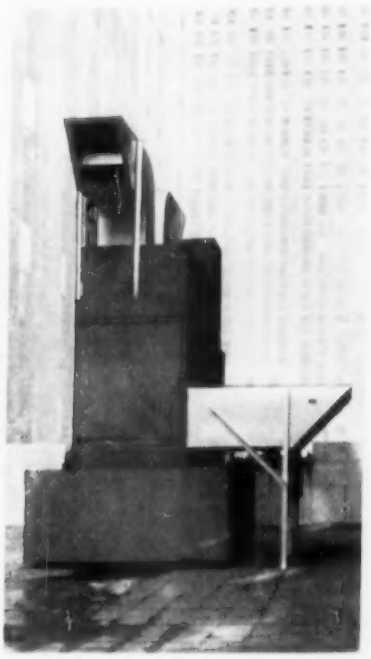


Fig. 4. Small evaporative condenser which has been effectively silenced, to prevent annoyance to nearby tenants

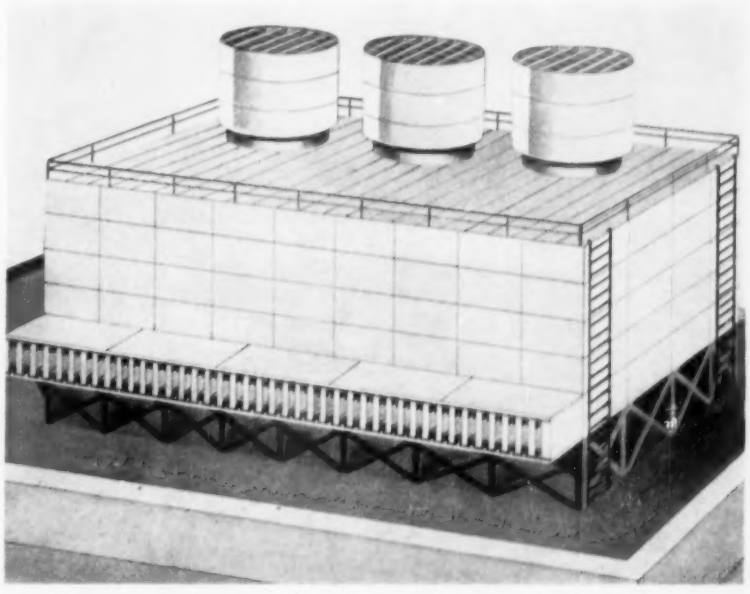
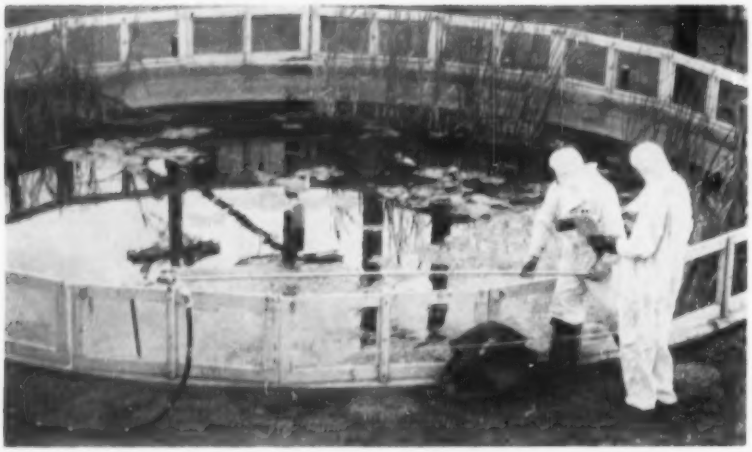


Fig. 2. Large cooling tower installation completely enclosed with modular "Soundmetal" panels. Note intake and exhaust air baffles, of acoustical construction

POWER ENGINEERING'S NEWS REEL



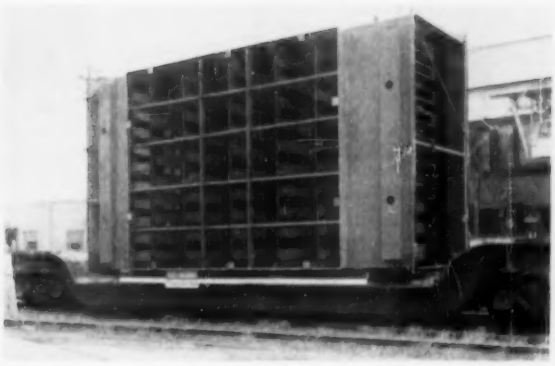
Harmless lily pond is actually a test tool for atomic plant at Hanford, Wash. GE biologists spike pond with radioactive cesium, a fission product, study its effect on frogs, plants, other life

No bigger than half dollar is new lead dry cell battery, compared here with conventional type. It is ⅝-in. thick, delivers 9/10 v, has capacity of 1½ amp-hr, indefinite shelf life, weighs 1½ oz. Made by Naval Ordnance Lab

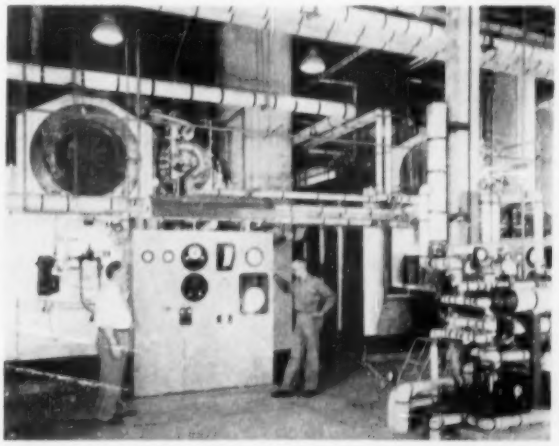
◀ **Not a cheese,** but American power know-how on its way to Belgium. It's the bull gear of a huge De Laval propulsion unit built to power a tanker

2200-ft conveyor belt, one of mining's largest, has been successfully repaired and returned to Mesabi Range by Conveyor Belt Service, Inc ▼

South American hydroelectric power gets a big new addition in the $13,500,000 Laguneta project in Colombia. The station can produce 54,000 kw. This shows the penstock tubes, each 6½ ft in diam, which bring water from Bogota River. Colombia expects to be producing 3,000,000 kw

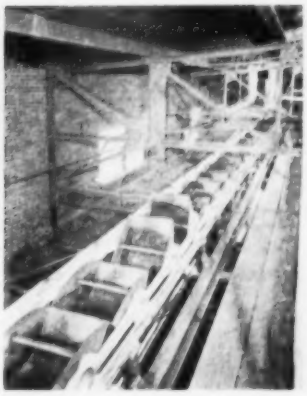


Steady now is watchword as this monster rolls along at 15 mph over the rails from Allis-Chalmers plant in Wisconsin to the West Coast. It's a 42,500-sq ft condenser for California Electric Power Co. Trip took 20 days, could only be made during daylight hours, with no oncoming rail traffic



New plant of the Okonite Co at North Brunswick, N. J., gets steam from two B&W 300-psi oil-fired boilers big enough to supply a 40,000-ton transoceanic tanker. System has Marley cooling tower, to reduce consumption of water

Button, button—but the game's the serious one of seeing to it that steam-generated electricity is produced economically. These are the desk-mounted controls of an electronic wizard called an Incremental Loader, built by Minneapolis-Honeywell and used by Niagara Mohawk Power. Loader takes command signal, apportions load to 6 generators



52,000 miles since 1904 is the record chalked up by this Link-Belt coal-handling system in Louisville & Nashville R.R.'s shops in Louisville. It has dumped some 3,000,000 tons of coal into the bunkers

Locomotive Maintenance Records Prove Gas Turbines Rugged

Union Pacific's experience since 1952 indicates that controls and auxiliary components are chief sources of trouble, much of which is nuisance variety. Turbines themselves are reliable and set records for moving more ton-miles per month at higher average speed

GAS-TURBINE locomotives on the Union Pacific have never been required to endure a tropical monsoon nor negotiate passage through a typhoon or hurricane, but there are few other climatic experiences that have been missed.

Currently the 25 gas-turbine locomotives are assigned to freight service between Council Bluffs, Iowa, and Ogden, Utah. This run starts at 1000-ft elevation at the Missouri River, climbs steadily for 500 miles across Nebraska to 6000-ft elevation at Cheyenne. Thirty-nine miles west of Cheyenne the line peaks at 8000 ft elevation and then runs across Wyoming on a high rugged plateau, never dropping below 6000-ft elevation. The last 65 miles of the route drop down Weber Canyon in Utah to Ogden at 4300-ft elevation.

Weather conditions across the 1000-mile territory vary from hot and humid to very dry and dusty. Ambient temperatures from −30 F to +90 and 100 F are not uncommon. Dust and sand storms driven by very high winds occur regularly.

During operation the machine is subject to considerable vibration and shock from the rail and drawbar effects. In addition, surrounding air is contaminated with dirt from ballast and rail sanders. It is not feasible to provide complete air cleaning because of the large cleaning equipment which would be required.

The low-grade residual fuel required for economical operation imposes additional difficulties in combustion and fuel handling and adds to control complications.

Operating cycles make locomotive gas-turbine service much more severe than comparable service in a stationary power plant or pumping station. Track profile and traffic conditions necessitate frequent load cycling between idle and full power. A large number of shutdowns and startups are required to conserve fuel.

Maintenance Problems

The first of the Union Pacific's 25 gas-turbine-powered locomotives was delivered in February, 1952. Since then, many maintenance problems have arisen, some of which have been solved. Since a study of all the problems encountered would be too lengthy for this article, a record of the defects occurring during a typical month has been selected as representative. During that month the 25 operating turbines accumulated an average of 432 fired hours.

The table on page 137 shows the number of defects occurring to gas turbines and associated control equipment. During August there was a total of 22 reported defects with 14 locomotives involved. The defects can be distributed as 15 control failures, five turbine-component mechanical failures, a case of wear, and a failure due to manufacturing error.

This fault distribution points up the fact that gas-turbine performance records are being seriously hurt by failure of auxiliary components which are not as well designed as the machine itself. This is a situation which demands attention. Realizing that precise regulation is required in order to extract the utmost in efficiency from modern machines, the job is only half done when the precision control is not mechanically able to do its job satisfactorily.

Many of the control failures can be classed as *continued on page 137*

This is a condensation of a paper by Ross C. Hill, Union Pacific Railroad, Omaha, presented at the Gas Turbine Power Conference, Detroit. ASME Paper No. 57 — GTP-4.

Fig. 1. Blade erosion on compressor rotor. Erosion here occurs at tips, does not cause excessive centrifugal stresses

Fig. 2. Compressor stator blade erosion occurs at roots. It is indicated life between rebladings will average 15,000 hr

When planning a new power plant, don't skimp on your tool inventory. Proper maintenance, which safeguards your original investment, can't be done without adequate tools. In this 3rd article in a series, the author discusses . . . .

Tools and Stores You Need To Run That New Industrial Power Plant

By PAUL N. GARAY

ALTHOUGH at first glance an extensive tool inventory may seem to be a needlessly expensive investment, remember that probably 2 per cent of your original investment will go into yearly maintenance and upkeep of the plant. With currently expensive manpower, it is good economy to facilitate the maintenance work that will need to be done, by providing proper tools.

The ability of your crew to use tools must be determined. Give them whatever instruction is necessary to insure the right use of your equipment. Don't put a handful of expensive tools in a mechanic's hand and say, "There it is, fix it!" Supervision and education may be indicated.

Certain simple, basic truths should be stressed, such as: don't use screwdrivers to chisel or pry; don't hammer with anything but a hammer; use a pipe wrench only on a round pipe; nuts and flattened objects should be turned with a wrench of the proper size; keep tools in good condition; specific tools are made for every job, don't use a tool for anything but the job for which it was designed. Here the National Safety Council can give valuable tips. Also valuable as a source of information on the use of tools are the instructions put out by the Armed Services for the training of their apprentices, boilermakers, machinists, firemen, metalsmiths, and other trades.

A general list of tools is suggested here. For a detailed inventory of tools as used by a medium-sized industrial power plant, write The Editor of POWER ENGINEERING.

PRECISION EQUIPMENT
- Vernier calipers
- Micrometers
- Rule
- Level
- Inside and outside calipers
- Divider
- Compass
- Bearing Scrapers
- Bearing puller
- Feeler gages
- Pointer lifter
- Square
- Tachometer
- Torque wrench

ELECTRICAL TEST EQUIPMENT
- Neon test lamp
- Multimeter
- Fuse puller
- Grounded-type extension cords

TEST INSTRUMENTATION
- Portable CO_2 tester
- Test gages 0–60 psi and 0–300 psi
- Scale thickeners indicator
- Machinery stethoscope
- Surface thermometer
- Fuel oil testing equipment
- Water test equipment

LUBRICATION EQUIPMENT
- Grease guns (one for each type of grease)
- Engineer's oilers
- Oily waste safety cans
- Oil measure
- Oil cans (various sizes)
- Oil pumps
- Funnels

MACHINIST'S TOOLS
- Clamps
- Chisels
- Crowbar
- Drills and drill press
- Flaring tool set
- Files
- Gasket punches and gasket cutters
- Hammers
- Level
- Lettering punches
- Number punches
- Miscellaneous punches
- Pliers
- Pipe tools
- Hacksaw
- Screwdrivers
- Screw extractors
- Tin snips
- Handsaws
- Wrenches (open end, sockets, adjustable, box, allen)
- Threading and tapping tools
- Vises
- Bench grinder

WEIGHT-HANDLING EQUIPMENT
- Block and tackle
- Chain hoists
- Drum cradle
- Sling cables or chains
- Jacks
- Wheelbarrow
- Hand truck or dolly

PORTABLE ELECTRICAL TOOLS
- Portable grinder and sander
- ¼-in. and ½-in. electric drills

WELDING AND CUTTING EQUIPMENT
- Butane torch
- Gas-welding equipment with cutting attachment
- Electric welder
- Gas soldering set

EMERGENCY AND SAFETY EQUIPMENT
- 2000-watt portable generator
- Portable electric vent blower with suction tube
- Hand lanterns
- Automatic battery spotlights
- Fire extinguishers
- Fire hoses
- Foam fire fighting equipment
- Safety hats
- Goggles
- Respirators
- Low voltage boiler extension lamp

BOILER REPAIR TOOLS
- Tube rolling equipment
- Insulation and brick tools
- Safety valve gags
- Special wrenches
- Special tools for fuel burning equipment
- Steam hose

MISCELLANEOUS EQUIPMENT
- Air hose
- Water hose
- Ladder
- Cleaning gear
- Waste cans
- Plumb bob
- Carpenter's tools
- Sewer snake
- Surveyor tape
- Industrial vacuum cleaner
- Hammer drill attachment for electric drill
- 0–30-lb scales
- Bilge pump
- Valve repair equipment
- Pickax
- Shovels
- Rake
- Hoe

OFFICE EQUIPMENT
- Furniture
- Storage
- Office machines
- Bulletin board

Fig. 1. Provide work bench and vise at a location convenient to tool crib, machinery, street door for shipping or receiving

Fig. 3. Library and filing system are just as much a tool for the well-run plant as are instruments and lubrication stores

Tools should be properly inventoried and stored in locked cabinets or cribs. For a small plant it is inconvenient to require tool chits, but to avoid losses, each tool should be put away at the end of each shift. Store tools in visible locations, and when a tool is removed, hang a white plaque in the empty space. In this way, any missing tools can be readily spotted.

As a precaution against theft, keep a list of serial numbers of your tools. Very often stolen tools are recovered from local pawnshops by tracing the serial number.

Work spaces should be set up to be convenient to toolroom, and should be provided with ample light. Make allowance for handling heavy valves or machinery, and have compressed air conveniently available.

Fire Fighting Precautions

Your tool list will include the necessary equipment for fire fighting and for other emergencies.

The most important single fire fighting item, of course, is the hose. When purchasing or installing hose, keep in mind the following requirements:

Hose must be kept ready and connected. An accordion-fold storage rack serves as well as reel-type storage, the difference being chiefly in the convenience of racking the hose. The hose should be kept connected to a pressure line at all times, with the shut-off valve immediately alongside the hose rack.

Test hose yearly under full line pressure. If using the accordion-fold rack, vary the points at which the folds occur.

Hose must be able to reach any part of the plant.

Hose must be accessible from any part of the plant. Consideration should be given to installing multiple hoses, for in case of a fire, one hose rack may not be accessible.

Each main floor should have its own hose.

Each fire hose should be fitted with its own nozzle. In case of oil or chemical fires, fit a convertible nozzle, which is adjustable for a stream, a spray, or a foam. To produce foam, a pick-up tube attached to the nozzle is dipped into a can of foam material (which should also be stored near the hose station). Foam is an excellent smothering medium to use in case of oil or chemical fires. Hose size needn't be overly large; the $1\frac{1}{2}$-in. size is ample for all needs.

Paint the immediate vicinity of the equipment red or orange, and put up a large sign, visible everywhere, stating: "Fire hose station. Do not use on electrical fires or on wiring."

Of course, the best of equipment is of no use unless it is properly used. Get your local fire department to send out a man to explain the how and why of simple fire fighting.

To complete your fire fighting equipment, provide an easily accessible water-type extinguisher, for fighting waste basket and trash fires. Inspect this twice yearly.

For small oil fires, and for *all* electrical fires, it will be necessary to have available a CO_2 fire extinguisher, or as many as are needed to be readily reached from any part of the plant. Get the type with the squeeze grip, for these can be used without completely discharging. Weigh them twice a year, and be sure to have a report turned in whenever they are used, as they should then be refilled.

The location of the extinguishers should be plainly marked and labeled, as in the case of fire hose. Keep attached to each bottle an inspection tag plainly marked with date and weight.

As for the common type of fire extinguisher using liquids such as carbon tetrachloride: the liquid in such extinguishers when it comes in contact with a hot surface will evolve a very lethal gas similar to phosgene. It is possible to inhale a fatal dose in one good breath. Use either water or CO_2. The CO_2 bottles in permanent racks should be the 15-lb size, but a small hand size is also available.

In general, remember that you may have three types of fire to combat: 1. solids, such as wood, trash, paper, oily cloth; 2. oil fires; 3. electrical.

Remember to fight these as follows: 1. with solid stream of water; 2. with water spray or foam — CO_2 may be used on small oil fires; 3. with CO_2 and nothing else.

An automatic lantern may be desired if it is necessary to provide light in case of power failure. Mount this overhead so that it will illuminate the given area in case of an emergency "lights out."

Provide a couple of sawhorses for use as barricades, and the necessary flags and warning signs. If you plan to open a street manhole, this equipment should be supplemented by flashing lights.

Planning Work Spaces

Necessary for proper plant operation and upkeep is the proper arrangement of work spaces. Provide a work bench and vise at a location convenient to the tool crib, the machinery, the street door for shipping or receiving machinery.

Oily waste cans, trash cans, and scrap metal cans should be provided. See that compressed air is available, and mount the grinder nearby. Provide a covered, air-tight garbage can for storing clean wiping rags. Do not use waste, as waste may cause trouble if it gets into machinery.

Arrange convenient storage of cleaning gear. Locker space should be provided, and, of course, adequate wash-up facilities. An item not usually seen in the average plant is a washing machine, but if your crew uses uniforms or overalls, a washing machine will be a great boon.

Paint is more expensive if bought in small cans, but unless you have a lot of painting to do, get the small cans, to avoid drying up of unused portions. When considering painting floors, remember that paint on concrete floors usually doesn't stick too well. However, if you get a special concrete paint, it will enhance the looks of your plant and solve the oily concrete floor problem.

A bulletin board will be useful for orderly posting of schedules, safety notices, plant notices, and other information. Make a practice, though, of cleaning up the board at least once every two weeks. A small blackboard centrally placed will be very useful for leaving instructions, making notes or diagrams.

Instruments should be stored in such a way that they will be checked frequently; also, they should be centrally available. Since they will be used frequently and are usually not rugged, a good place for them is in a cabinet in the chief's office.

Spare Parts

The stowage of spare parts can be handled in two ways, depending on your plant and individual requirements.

1. The spare parts to fit any machine may be put into a small box which is mounted near the machine, with the contents listed on the cover. This is convenient, but may lead to some duplication of parts. In case repairs are contemplated, it is a simple matter to look into the parts box and make sure that all the required parts are available. If this system is used, check the boxes frequently. Special tools can also be stored in these parts boxes.

2. All spare parts can be kept in central stores, and maintained by inventory. This is the system used in larger plants, and, if records are properly maintained, assures that parts are always available and ready. If several machines use one type of repair parts, this system will result in a minimum inventory. Central information is also available with this type of stowage.

Fig. 3. Bulletin board is indispensable but be sure to clean it up regularly

Consumable Stores

Certain materials, which we can correctly call "consumable stores," should be maintained in constant supply. These are the materials used up in day to day operations, or in routine service and maintenance. Provision should be made to see that such stores are automatically placed on the order list in sufficient time to permit new stocks to be received before you run out of the old.

A sample item of this type is salt for regeneration of feedwater softeners. A daily checkoff list of the consumable items can be kept, and items put on a "materials required" list, and given to the chief engineer for action.

When making up your list, consider the following: How much is used daily? How long will delivery take? What is the time lag between requesting a supply and receiving it?

In the case of salt, in our plant we used two 100-lb bags a day. Delivery was usually three days, and we could conveniently store forty bags. (This is determined in part by savings on quantity purchases.) Therefore, when our stock was down to eight bags, the order was placed, and we received our new supply in time to maintain continuous operation. The minimum level of stock is noted on the checkoff list, so that the clerk who makes the check will put in a "materials required" note at the proper time.

Consumable items include fuel, fuel oil additives, welding gas, kerosene, packing material, wiping rags, greases, oils, sanitary materials, feedwater treatment chemicals, and other materials as required.

Packings in this category are the general purpose sheet, coil, or roll packings. In our case, we found that four types, each in a range of sizes, served all our needs. These were: cold water, hot water and low pressure steam, high pressure steam, and oil. The roll packing was stocked in sizes from $\frac{1}{8}$-in. to $\frac{5}{8}$-in. by $\frac{1}{8}$'s, and sheet packing was in $\frac{1}{16}$-in. or $\frac{1}{32}$-in. thicknesses.

Greases come in a multitude of grades, but your requirements will usually be served by a high temperature grease for soot blowers and hot bearings, a medium temperature all-purpose grease, and a cold grease for such application as cold water pump shafts.

Oil can be a complex supply problem. We solved our own particular situation by requesting an oil supply firm to study our requirements. They recommended a single grade of oil which was suitable for our turbine bearings, reduction gears, compressors, engines, and all our requirements. With the exception of a very small amount of a heavy gear oil which we stocked for a few gear cases, our oil requirements were served by this one grade, which we bought cheaply in drums.

Library and Filing System

A plant library and filing system should be established, to organize your sources of information. Your first file, of course, should be the blueprint file, which will contain the large blueprints for the plant. This should preferably be a suspended-type storage rack, which can be inexpensively made. Your plant blueprint file should contain plan and elevation views of buildings, flow diagram for the systems, piping diagrams, electrical layouts, machinery and equipment layouts in plans and elevation, and prints of large items such as boilers and other key items, showing the relation of these items to the plant layout. If possible, ask the design engineer for a heat balance diagram.

Then establish a file for storing the records discussed in the chapter on setting up records for the new power plant (October, 1957 issue of POWER ENGINEERING, page 86).

A file will be needed for equipment manufacturers' instruction manuals. Each manual should have operating information, repair information, parts (lists, preferably with approximate price shown on each item), recommended spare parts, performance data, and drawings.

A file will be needed for catalogs which are issued by sales departments of manufacturers and by supply houses. These catalogs contain much technical and engineering information. This file will be useful when selecting new or replacement items, or planning improvements. Then, too, you can follow the progress of an industry by noting the types of equipment being made available.

Other library tools will include: a correspondence file for keeping all letters, bills, documents, guarantees, and other unassigned written material; a shelf of technical books for ready reference; a file of technical magazines.

Sources of information should be diligently investigated both by your operators and chief engineer. Consider membership in such organizations as the American Institute of Plant Engineers, the National Association of Power Engineers, as well as in those numerous other technical societies which are organized for exchange of technical information and the furthering of technical proficiency. THE END

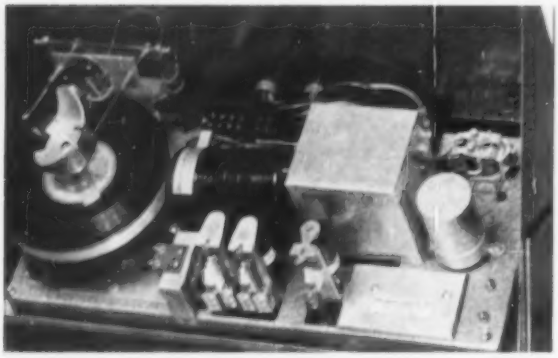


Fig. 1. Close-up of the interior of the automatic ice-warning unit, showing the various components, including the phono disc, motor, and relay mechanism; no radio equipment shown

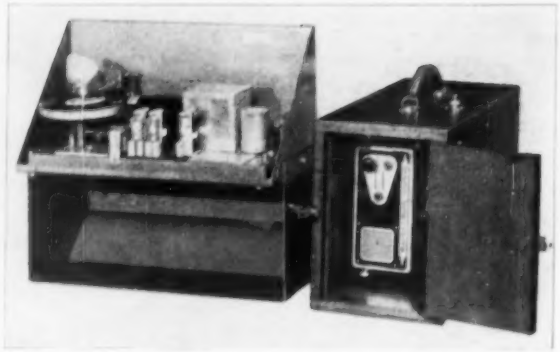


Fig. 2. Complete ice-warning station is shown with covers removed. On the left is seen the automatic warning unit; the portable "Reporter" radio transmitter is on the right

Automatic Warning of Ice on Power Lines

Hydroelectric Board of North Scotland develops completely automatic warning system to detect ice formation on isolated power lines. Ice can then be melted off, to prevent rupture of conductors

By F. C. LIVINGSTONE

THE NORTH of Scotland is the wildest and most mountainous part of the British Isles, and it is the only section of the country which is not linked in the National Grid system, which provides almost uninterrupted distribution of electric power in every corner of the land.

Peculiar geographic position and climate of its 20,000 square miles area, and its exclusion from the Grid hook-up, gives the North of Scotland Hydroelectric Board many problems to solve. Not the least of these arise because most of its generating stations are located in the west of Scotland. Here the rivers and big lakes have been tamed to provide hydroelectric power; while the vast bulk of its customers are in the east and northeast, on the other side of the Cairngorm and Grampian mountains, Britain's highest ranges.

The transmission problem is particularly acute in the winter months, when even the main roads across the mountains are often completely impassable to all forms of vehicles, for weeks on end. Wherever possible, the 132 kv transmission lines parallel the highways, so that, whenever possible, maintenance is made as easy as can be. But this does not solve the problem of dealing with ice-laden lines when the roads cannot be used.

Searching for a means of keeping the transmission lines in service, and having advance warning of ice forming on them, the North of Scotland Hydroelectric Board engineers chose the Lecht Pass for their experiments. The pass carries the main road across the northern ridges of the Cairngorms at a height of 2090 ft above sea level. It also carries the transmission line to Aberdeen, the biggest city in the east of Scotland. From late December to mid-April, the road is completely blocked by snow.

Due to the great height of this line, coupled with the very cold and damp air associated with the Cairngorm area in winter, the formation of ice on the line is a frequent occurrence during the winter months. If the ice buildup is allowed to go unchecked, an actual failure of the line can take place. Also, due to uneven icing, one phase can sag causing a short between phases.

It was, therefore, going to be a great advantage to the Control Engineer at Aberdeen if he could be made aware of the presence of ice on the line at the Lecht Pass. Pye Telecommunications, Ltd were consulted; and, in conjunction with the Board's engineers, developed, in a very short time, an automatic warning system.

The original idea was to have an endless magnetic tape carrying a recorded message, which would be repeated several times at spaced intervals, and transmitted back to the Control Center at Aberdeen. A strain-gauge would be fitted to the overhead cables to provide a mechanical indication when ice was forming. This idea was found not to be practicable, however, due to the heavy power supply requirements of the tape motor and necessary amplifiers.

As there was no suitable power at the Lecht Pass, it was eventually decided that the equipment to be supplied must operate from storage batteries. Also, it must have very low power consumption in order that one set of batteries could last the whole of the winter period, when the Pass was inaccessible, without being charged. It was found that the Pye Reporter transmitter would meet the power requirements; then a device consisting of a phonograph turntable, and this transmitter was soon developed.

A strain-gauge was inserted between the insulators on the power cables and the top of the tower, which is situated at the head of the Pass. This gauge was set at 2600 lb, which covers the tension normally experienced by the pressure of wind on the cables. If this tension is exceeded due to weight of ice forming on the line, a closed circuit condition is presented to a relay located in the refuge hut below the tower. This in turn switches on the modified transmitter and turntable device housed in the hut.

After a short warming-up period, the turntable revolves and plays a 6-in. phonograph record containing a two-minute message: "Ice forming on Lecht", into the Reporter transmitter which transmits the message back to the control room in Aberdeen. This process is repeated every 15 minutes for as long as the strain-gauge is showing a tension exceeding 2600 lb.

The message is received at the board's remote VEF radio station, 60 miles away at Cairn-mon-Earn, and re-transmitted automatically to the Aberdeen Control Room.

When he receives the warning, the control engineer can isolate the 132 kv line, and impose the output of a local generator on to the line to overload it. The heat thus produced melts the ice. Once the warnings from the Lecht Pass cease, the overload is taken off, and the 132 kv line is restored to bring electricity from the west. So, another damaging power failure is averted. THE END

Salt Water to Fresh—Several Ways

Water shortage in recent years has accelerated research in clarification of salt water. Here is a review of activity in this field, with the pros and cons of the most practical methods in use today

IF YOU'RE planning on a life of solitude on a desert island, don't overlook the water problem; fresh water, that is. Even if you are surrounded with water, you can't drink it, unless the salt is removed; this seemingly simple process is quite expensive, and involves a lot of equipment. Both initial cost of equipment, and operating costs, are high, as compared to fresh-water costs. Of course, almost any cost is reasonable, if that cost is necessary to sustain human life; however, with present known methods of producing potable water from salt-water, the cost makes it entirely uneconomical as an industrial or irrigation source.

Three Approaches to Problem

Producing fresh water from salty or brackish water can be accomplished by three techniques: chemical, electrical, and mechanical. A review of the three might be of some help to those power engineers interested in this particular subject. Not all of these engineers are located along the coastline; many are concerned with the problem of demineralization of brackish water, in many inland locations.

Mechanical desalting of water is the most economical of the several methods, and by far the most widely used. This is simply a distillation process, in one form or another. For years, fresh water on board seagoing ships has been obtained through either submerged-tube, flash-type, or vapor-compression distilling equipment. Steam-driven ships use the flash-type, because of the availability of low-pressure steam as a heat source. Those ships which are deisel-driven do not have a general source of heat, and must rely on the vapor-compression type of equipment.

While the submerged-tube type of distilling unit has been the most widely used, flash-type equipment is rapidly coming into common use. In general, the submerged unit has been built in sizes ranging from 4000 to 120,000 gpd of distilled water. Also, the units are fabricated in one, two, three, and occasionally four stages, or "effects." A simple single-effect unit is an evaporator wherein heat is added to a quantity of salt water to produce steam, which is then put through a condenser, and condensed into distilled water.

To increase the efficiency of the operation, more effects are added; in such cases, the condenser of the first stage becomes the boiler of the second stage. From this point, steam emerges at a lower temperature and pressure, and passes to another condenser. The number of effects is determined by the temperature differentials available to produce economical rates of heat transfer. A diagramatic sketch of a two-effect, submerged tube unit is shown in Fig. 1; this equipment will produce 12,000 gpd of distilled water, using 2240 pounds per hour of 5 psig steam. The circulating water, for condensing and make-up, amounts to 240 gpm, or 120,000 pounds per hour.

A distinctive characteristic of all submerged-tube units is that each effect contains an evaporator tube bundle in the bottom half of the shell; hence its name. Low pressure steam is used as the heat source inside the bundle, and boiling salt water is on the outside of the bundle. Ratio of feed-to-distillate runs between 3 to 1, and 2 to 1; the exact ratio being determined by the scaling function.

Flash-type distilling equipment, for distillation of salt water, has developed more recently; at present, it is supplied in sizes ranging from 8000 to 50,000 gpd, and in stages of from two to five effects. These units have no evaporator bundles; the cycle of operation is this:

1. Heated sea water is introduced into the bottom of the shell, of the first stage; 2. A partial vacuum is attained, causing a certain amount of flashing to occur; 3. Excess salt water automatically overflows to the bottom shell of the second stage; 4. Pressure drop is again effected; 5. Vapor is condensed, cooled, and sent out as distilled water.

Distillation in a two-stage flash unit is shown diagrammatically in Fig. 2; this typical unit requires 2240 pounds per hour of 5 psig steam, and produces 12,000 gpd of pure water.

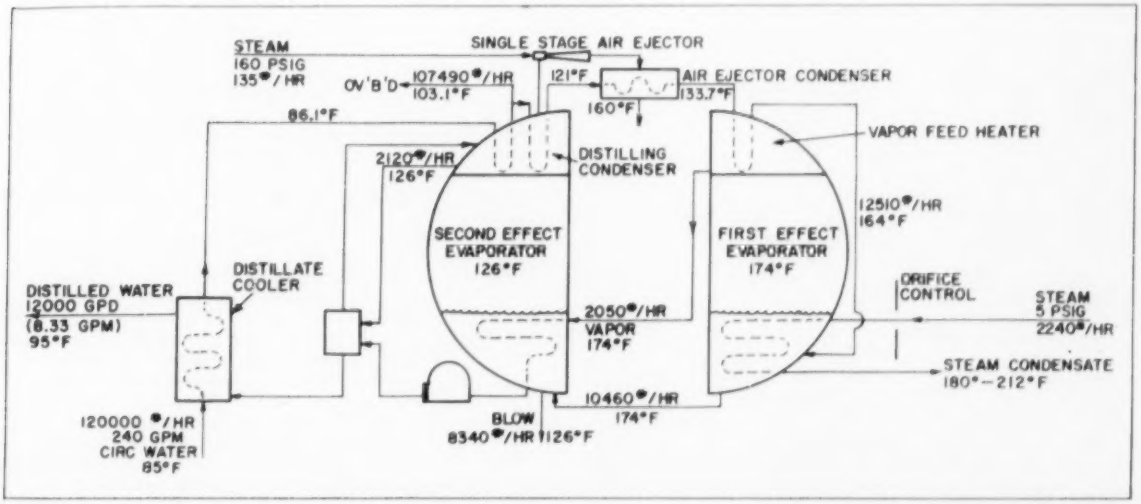


Fig. 1. Diagram of two-effect, submerged-tube evaporator. This equipment will produce 12,000 gdp of distilled water, using 2240 lb per hr of 5 psig steam. Circulating water for condensing and make-up amounts to 240 gpm, or 120,000 lb per hr

Vapor-compression distillation is unique in that the heat for distilling is not supplied from an outside source; instead, it is derived from the continuous reuse of the latent heat of vaporization, by compression of vapor. A diagram of a simple unit of this type is shown in Fig. 3. It will be noted that a starting heater brings the incoming salt water up to steaming temperature; the steam thus generated is put through the steam compressor, and compressed to 3 psi, and 222 F. This cycle furnishes the heat for distillation, from an outside mechanical source; the motive power for driving the compressor can be either electric or mechanical.

The higher-pressure steam, caused by compression, is evaporated in the evaporator shell; the condensate is sent through a heat exchanger and is discharged as distilled water. This same heat exchanger gives a temperature boost, also, to the incoming salt water; heat is extracted from both the outgoing brine solution, and from the hot distilled water. The entire equipment is basically a "Kleinschmidt still", and a heat pump, as well.

Chemical demineralization of salt water is not considered economically feasible, if large quantities of water are required. Organic anion and cation exchangers will produce *complete* demineralization, and their most important application is in those industries requiring such a degree of clarification. Cost and feasibility of demineralization depend upon the salinity of the water before treatment; therefore, it is not practical to treat sea water having approximately 34,000 ppm total dissolved solids.

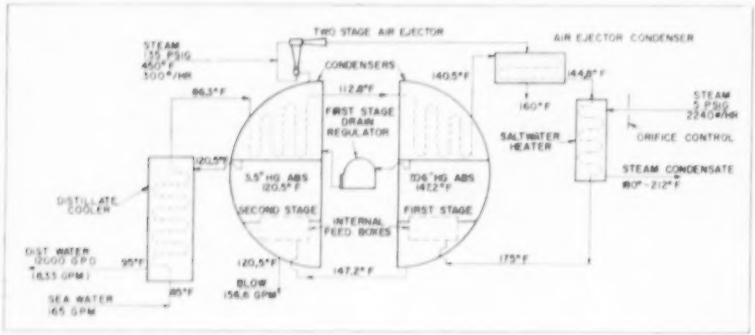


Fig. 2. Two-stage flash still, shown diagrammatically. This equipment also produces 12,000 gpd of distilled water, utilizing 2240 lb per hr of 5 psig steam

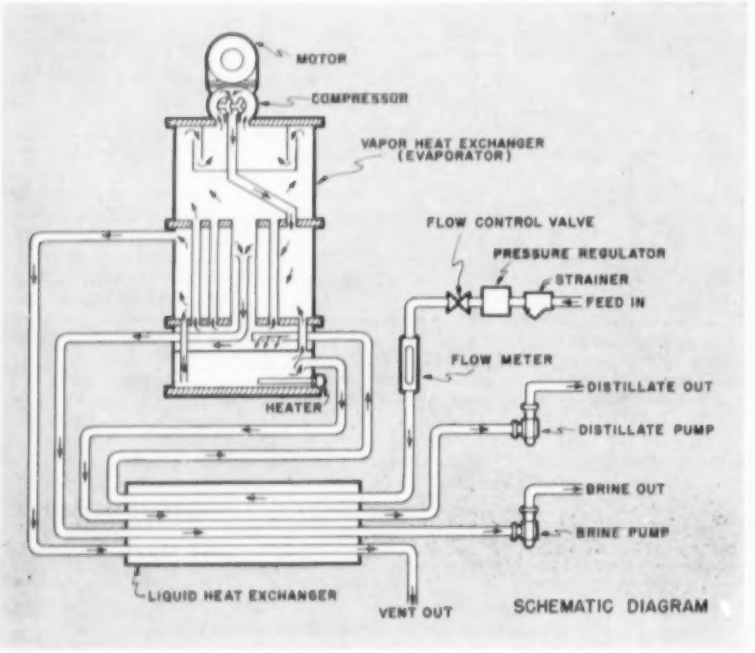


Fig. 3. Vapor-compression still using no outside source of heat. Starter heat unit brings water to steaming temperature; then compression of steam continues process

The process is entirely chemical, and there are no requirements for external sources of heat or power.

Electrical demineralizers differ from other types, in that they *remove the salt from the water*, rather than the reverse of this. Membrane demineralizers, developed by Ionics, Inc, provide a very satisfactory method of obtaining fresh water from salty or brackish water. In this process, salt is moved by an electric current, through special membranes, out of one stream which is being desalted, and into a second stream which becomes a brine and is discarded.

Ionics equipment operates on the principle of physical separation of salt from water, by ionization and the use of special plastic plates which separate waste from product. These plastic plates are known as ion-transfer membranes; they are of two types: one allows positive ions only to pass, while the other permits passage of negative ions only. When these sheets are stacked alternately, and separated so water can flow between them, an electric current sent into the water will cause the mineral ions to travel into alternate spaces. The clear water will then remain in the other spaces, and can be taken away as "product," or clear water.

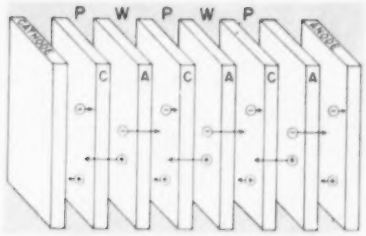
A suitable arrangement of gaskets, separators, enclosures, and piping makes a completely closed system of the apparatus. A source of direct-current is impressed upon electrodes at each end of the stack of membrane sheets; a diagram of such a stack is shown in Fig. 4.

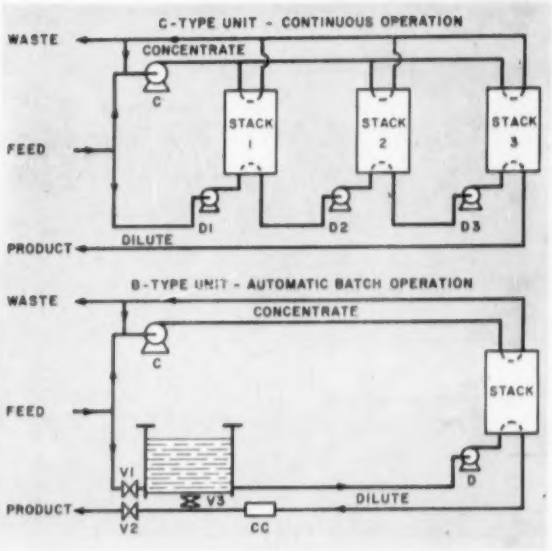
Salinity vs Output

Like all demineralizers, this membrane type has a production rate dependent upon the salinity of the incoming water. Commercially, the stacks of membrane demineralizers are limited to two types depending on the production rate desired. Maximum output of either size can be obtained with water of lowest percentage of salinity; conversely, the higher the salinity, the greater the effort required to reduce the product to acceptable standards. Multiple units can be used, or the clarified water can be recirculated through the one stack. Ionics' units are rated at 28,800 gallons daily, for the "B-type"; the "C-type" units are for production rates up to several million gallons daily.

In normal practice, a single "B-type" stack is used in an automatic batch operation, for volumes up to 20 gpm recirculation, with a demineralization of 40 to 50 per cent for each pass through the stack. The operation is made automatic with the addition of a conductivity-measuring cell, operating automatic valves. This arrangement is illustrated in Fig. 5, and shows the connections for one stack, tank, automatic valves, conductivity cell, and pumps.

Larger quantities of clarified water can be produced in a multiple-stack assembly as shown in Fig. 5. Here a





Figs. 4–5. Diagrams above and to the right illustrate graphically the operation of ion-transfer membrane demineralizers. Above sketch gives schematic layout of positive and negative plastic membranes which separate waste from product. Two diagrams at right show arrangements of "B" and "C" type Ionics units, together with related equipment, to complete the installation. Multiple units are used to increase the total capacity of the distillation equipment. A direct-current source must be applied to the stacks; this can be supplied from rectifiers or motor-generator sets. Principal advantages of this equipment are its simplicity, and its low operating cost

40 to 50 per cent reduction in salinity will be gained, in the remaining salt level, through each stack. The number of stages required will depend on the raw water salinity, and the degree of purification acceptable.

Cost Depends on Many Factors

Water desalting is expensive, both in capital investment and in operating expense; however, the end justifies the means, if no fresh water is available — and must be provided at any cost. Since a study of the economics of water desalting must necessarily include both equipment and operating costs, it is well to get some idea of both. Looking into data furnished by several manufacturers, we find these approximate figures:

Operating Expense (Per 1000 gallons)

1. Distillation—3-stage evaporation	$ 1.00 to $ 1.50
2. Vapor-Compression method	1.25 to 1.50
3. Organic chemical exchanger	20.00 to 25.00
4. Ion-Exchange Resin type	1.80 to 3.60*

(* Based on 7 kwh per 1000 gal for each 1000 ppm salinity reduction.)

The above figures are general, and cannot be used as a basis for estimating an actual installation. They all apply to sea water containing 35,000 ppm salinity; as the concentration decreases, so does the cost. In brackish water applications, all of the methods present much better economies. Steam, and electric power costs will vary widely in different installations, also. Some applications may be able to utilize waste heat from an associated manufacturing process, and this will reduce the operating cost.

Demineralization of salty, or brackish, water has been the subject of much research, in government agencies, universities, and in private industry. And, the research continues; accelerated by the promising advances in the last two years. The Department of the Interior has done much work in the field, both by direct contracts to research organizations, and by coördinating and publishing the results in all fields of endeavor.

Research in Various Methods

Dean Everett D. Howe of the University of California, has directed considerable research in the field of demineralization of salt water, for the State of California. (Department of the Interior has participated in much of this work, by direct grants of funds.) The Griscom-Russell Co, has been building marine heat-transfer equipment for over 80 years, and has been conducting a continuing research program in desalting.

Electric membrane demineralization has been perfected by Ionics, Inc. The commercially available units produced by Ionics are the result of many years of research and field operation.

A new type of centrifugal compression still has been announced by Badger Manufacturing Co, a leading producer of vapor-compression water stills. This new equipment was developed by Badger, from a process conceived by Dr. Kenneth C. D. Hickman. A full-size pilot model has been constructed, under a research grant from the Department of the Interior. This unit is capable of producing 1000 gallons of distilled water from a 3000 gallon input of salt water; the power input is 60 kwh per thousand gallons. If operated on an electric rate of one cent per kwh, the distilled water would cost 60 cents per 1000 gallons, which is well within the feasible cost limit of such distillation.

This revolutionary unit, known as the Badger-Hickman Still, embodies an entirely new application of *recompression distillation*. Instead of using a conventional tubular boiler as an evaporator-condenser, the apparatus utilizes a rotating assembly of paired copper discs. These discs are mounted on a rotating shaft, and are so installed that they become revolving drums. They are heated to about 150 F; then salt water is sprayed onto the inside of the drums. Some of the salt water evaporates as low-temperature steam; the balance is drained off, in the form of concentrated brine solution.

The steam evaporated from the drums is collected, and compressed, to raise its temperature. Then the compressed steam is passed over the outside of the drums, where it is condensed into pure water. This cycle also helps to heat the evaporator drums. Practically no external heat is used in the process; the steam compressor does the job. Energy is supplied by the electric motor which drives the compressor; this, plus the driving motor for the rotating drums, is the total electricity required.

Dr. Hickman feels that the Badger-Hickman Still is the simplest possible form of distillation machine today. In the pilot model, the production rate is 33 gallons per minute; this unit is about 30 feet high, quite compact, and relatively inexpensive when compared to other equipment for the same end results. THE END

References

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2. Vacuum Distillation of Water in a Laboratory-Scale Thermal Difference Plant — L. Akobjanoff, E. D. Howe, Univ. of California.
3. Department of the Interior — Annual Report on Saline Water Conversion.
4. Sea Water Distilling Units — A Comparison of Types — Wm. A. Gardner, Griscom-Russell Co.
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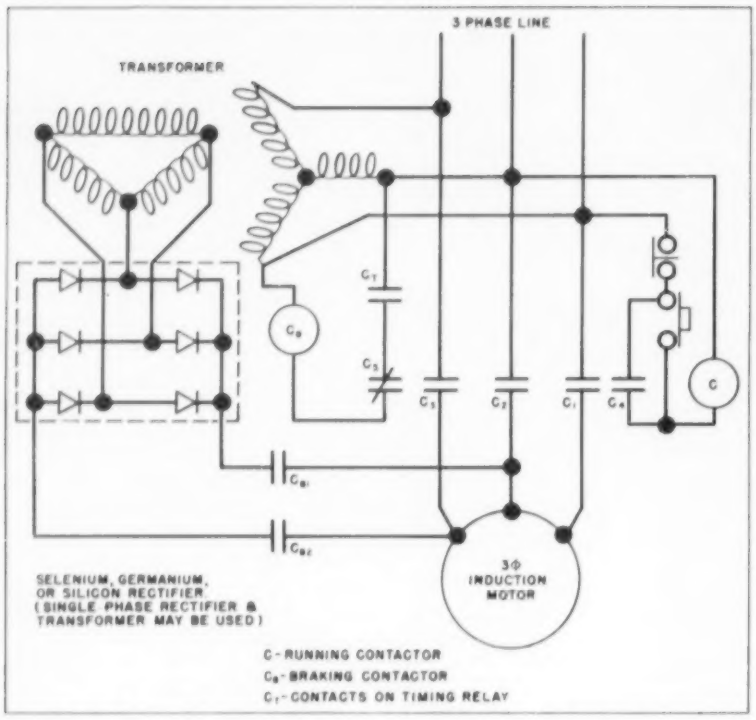


Fig. 1. Basic circuit for applying d-c braking to a three-phase induction motor

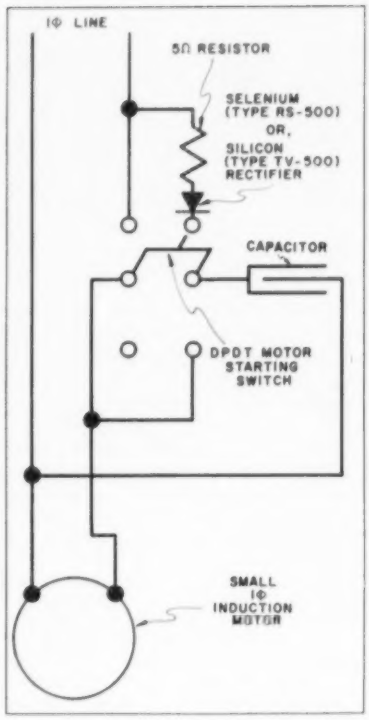


Fig. 2. Capacitor brake for small motor

D-C Braking for Induction Motors

IN MANY applications where induction motors are used, it is desirable to provide a retarding force to slow or stop the motor by a means other than a mechanical brake, or to supplement a mechanical brake. Direct-current braking, using metallic rectifiers for the d-c supply, provides a simple, effective and accurately adjustable method for stopping induction motors, according to F. W. Parrish.*

While there are several methods of electrically-braking induction motors, including plugging, regenerative braking, and capacitor braking, d-c braking provides a unique set of advantages under certain conditions. It is provided simply by applying a d-c voltage to one phase of a polyphase induction motor (or the terminals of a single-phase motor), usually from a transformer-rectifier power supply. The principle of operation is based on Lenz's Law and has been stated by Maxwell as follows:

"If a constant current flows in a primary circuit 'A', and if, by motion of 'A', or by the secondary circuit 'B', a current is inducted in 'B', the direction of this induced current will be such that, by its electromagnetic action on 'A', it tends to oppose the relative motion of the circuits."

In the induction motor, the primary circuit is the stator winding and the secondary circuit is in the rotor squirrel cage, or the winding in the case of a wound rotor motor. The braking force results from the opposition to relative motion between these two circuits while the direct current is flowing. This braking has the following attributes:

1. It is effective on all induction motors, single or polyphase, squirrel cage or wound rotor.

2. The amount of braking torque and the rate of braking are easily adjustable over a wide range, and the braking rate, when once correctly adjusted, will maintain and duplicate the retarding cycle accurately each time the cycle is initiated.

3. A smooth rolling stop is obtained by this method, but, like the other methods, there is no holding power at the end of the braking cycle, and on loads which must be firmly held, an auxiliary mechanical brake is required.

4. For rapid braking, direct currents in excess of rated motor full-load currents are required. Therefore, similar to plugging, overheating of the motor can occur if the power is applied for extended periods. Accordingly, a timer is usually used to remove the d-c power after the motor has stopped. It should be explained, however, that for an equal braking effort, the d-c braking losses are less than those of plugging.

5. If an adjustable auto transformer is connected ahead of the rectifier transformer, the direct current to the motor stator may be varied and the braking rate adjusted to suit variable loads such as cranes and hoists. In this way, loads may be lowered safely and smoothly, although an auxiliary mechanical brake is necessary to stop and hold the load.

The basic circuit, Fig. 1, consists of a three-phase transformer and rectifier feeding the motor terminals through the braking contacts of a reversing contactor. When the motor contactor, C, is de-energized, the braking contactor, C_B, is energized and applies d-c power until the timer contact, C_T, disconnects the circuit.

Figure 2 is a small-motor braking circuit using a charged capacitor.

For most power supplies to operate d-c braking installations, selenium rectifiers are preferred, since they have higher heat-storage capacity and correspondingly higher intermittent load-handling capabilities, as well as lower first cost than some other metallic rectifiers. However, where special conditions warrant their use, germanium and silicon rectifiers may be successfully applied to this type of load. THE END

* International Rectifier Corporation, in a paper published in *International Rectifier News*.

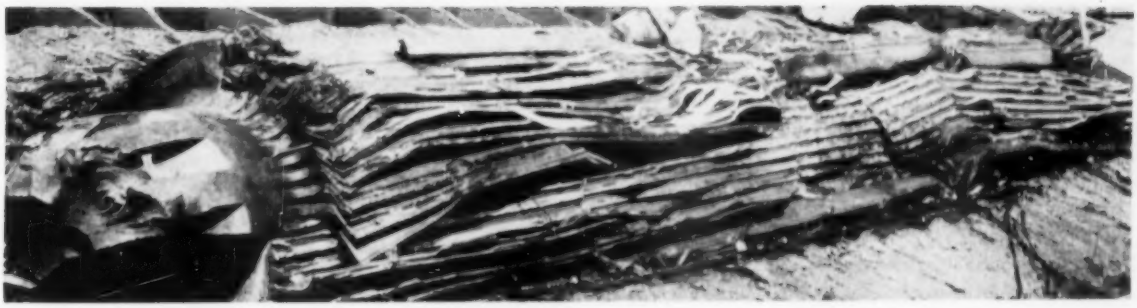


Fig. 1. View of Pittsburg rotor after accident, still lying in stator, but with half of the stator frame and core cut away

G-E Reports on Pittsburg Rotor Burst

IN A MEETING characterized by the coöperative attitude of the large generator manufacturers on a mutual problem, General Electric representatives presented their analysis of last year's rotor burst at Pittsburg, Calif.*

Cause of the failure was quite clearly indicated, so discussion centered on detection of such flaws, both in new forgings and in those rotors now in service which conceivably might hold such incipient dangers. Improvement of forgings in order to eliminate such difficulties in the first place was also discussed.

On March 18, 1956, the generator rotor of the 169,118-kva Pittsburg Unit No. 1, of the Pacific Gas and Electric Co, burst during an overspeed-governor trip test. This test was being made before placing the turbine-generator in operation following inspection and overhaul of the turbine.

Pittsburg station is an outdoor power plant having four duplicate 3600-rpm turbine-generators each rated 125,000 kw. The first of these, Unit No. 1, went into service in May 1954, and station records showed the unit had 51 starts and stops, and 30 overspeed-governor checks, with 10 of them at or slightly over 4000 rpm.

For about two months prior to the burst, it had been shut down for a regular inspection and overhaul. During the shutdown, ambient temperatures dropped to 40-50 F. In starting again, the rotor was overspeeded three times to check and set the emergency trip, and it was run intermittently at no load or light loads from the morning of March 17, to the evening of March 18, when, while checking the overspeed trip again, the rotor burst at 3920 rpm. The broken pieces of the rotor were contained within the stator.

Some damage to the turbine was caused by a sudden end thrust resulting from jamming of the generator rotor fragments. The turbine was repaired, and with a replacement generator, the unit went back into operation four months later.

* Investigation of the Generator Rotor Burst at the Pittsburg Station of The Pacific Gas and Electric Company, by D. R. DeForest, C. Schabtach, L. P. Grobel, and B. R. Seguin, Large Steam Turbine-Generator Dept., General Electric, at 1957 Power Conference, Allentown, Penna.

Description of Fracture

Rotor body burst lengthwise into two half-cylinders like a log split down the middle. The two halves then broke into smaller pieces. Figure 1 is a photograph of the field exposed after cutting away the top-half of the stator.

Visual examination of the fractured surfaces as the fragments were removed from the stator indicated that the origin of the burst was located in one fragment, about ten feet long, of the main body. The origin of the fracture was an area about 5 in. long axially, by 2 in. wide radially, located about 30 in. from the collector end of the body and nearly on the axis. This 2-in. by 5-in. area had a "woody" or fibrous appearance different from that of the fracture surface surrounding it.

Presence of fracture striations emanating from this "woody" area indicated that this was the origin of the fracture. Figure 2 is a photograph of a portion of the primary fracture surface containing the 2-in. by 5-in. area. As can be seen, there is no evidence of the common fatigue striations that would be present if this 2-in. by 5-in. area had increased in size by fatigue progression.

At the time the 10-ft section was removed from the stator, clusters of greenish-yellow particles typical of silicate-type inclusions were observed in the center of the 2-in. by 5-in. area.

Investigation

Year following the accident saw exhaustive efforts along several lines: 1, complete history of the rotor, from ingot to installation, was studied in detail; 2, acceptance tests were reviewed, including chemical and mechanical properties and ultrasonic test results; 3, visual examination of all fragments, with copious notes and photographs; 4, expansive tests of all properties of these fragments, and comparison with original test results; and 5, conscientious re-examination of the effectiveness of the tests, particularly the ultrasonic tests. Interest centered around the last.

Original sonic examination had indicated there were only two minor indications up to 25 per cent in magnitude in the vicinity of the fracture origin. From calibration of the sonic-test equipment, a 25 per cent indication showed the presence of something no larger than a dime. It was

1957 Power Conference, held at Allentown, Penna., under sponsorship of the Power Division of ASME, was covered by your editorial staff. Seam-bursting registration—490 men, 42 ladies—testified to the vital importance of the material presented. Portions of the power field explored included cooling towers, axial-flow-exhaust steam turbines, several aspects of major station construction and operation, and nuclear power.

Described here is testimony and discussion on the results of the investigation of the Pittsburg (Calif.) rotor failure last year.

POWER ENGINEERING in January will report on the axial-flow-exhaust turbine described at the meeting, and the system which adapts it for use with a Monotube steam generator. This interesting installation is for the the new Portland, Penna., Station of Metropolitan Edison Company.

Next fall the Power Conference will be held in Boston, and will be co-sponsored by the Power Divisions of ASME and AIEE.

concluded that the sonic indications were the result of small slag inclusions and the forging was accepted. (In cutting up nine rotors, and in the examination of 87 trepans from 30 other rotors, GE had never found cracks nor other harmful defects in a forging whose indications were within somewhat larger limits.) By sonic test, and by all the standards and experience available, this was judged to be a sound and serviceable forging.

Examination of Pittsburg No. 3

Difference between the size of the discontinuity actually observed and that indicated sonically was chief cause for concern. Unit No. 3 at Pittsburg was found to have shown similar sonic indications during manufacture, and so was subjected to sonic tests in the field in October, 1956, after about two years' service.

Indications were different from those observed during manufacture, when indications of five to ten per cent magnitude were recorded. The later test showed an indication of 40 per cent magnitude in the same locality. This was the first time GE had found a change in sonic-test results after a rotor was run, and they had retested 17 rotors after service.

A core 2¾ in. in diameter and 32 in. long in the vicinity of the sonic indication was found to contain a nearly continuous array of complex manganese silicate inclusions, covering an area about 1½ in. by 8 in.

It is reasonable to believe that inclusions existed originally at the 2-in. by 5-in. area in the No. 1 rotor because of the following similarities to No. 3 rotor:

1. Greenish-yellow silicates observed in the "woody" areas were similar.
2. Surface configuration of the 2-in. by 5-in. area of No. 1 was similar to the exposed surface of the 1½-in. by 8-in. plane in No. 3.
3. Surface of the area in No. 1, and the metal interface adjacent to the plane of inclusions in No. 3, were predominately intergranular.
4. Both 2-in. by 5-in. area in rotor No. 1, and plane of inclusions in No. 3 rotor were located along centerline and about the same axial distance from the end of the body. In addition, these areas were toward the top of ingots from which forgings were made. It should be noted that top part of the ingot was exciter end of No. 1, and turbine end of No. 3.
5. Both rotors showed minor sonic indications from areas of inclusions when tested before service, but in neither case was size of sonic indications indicative of size of inclusion present.

Fig. 2. Origin of fracture is shown in photograph of segment removed from rotor

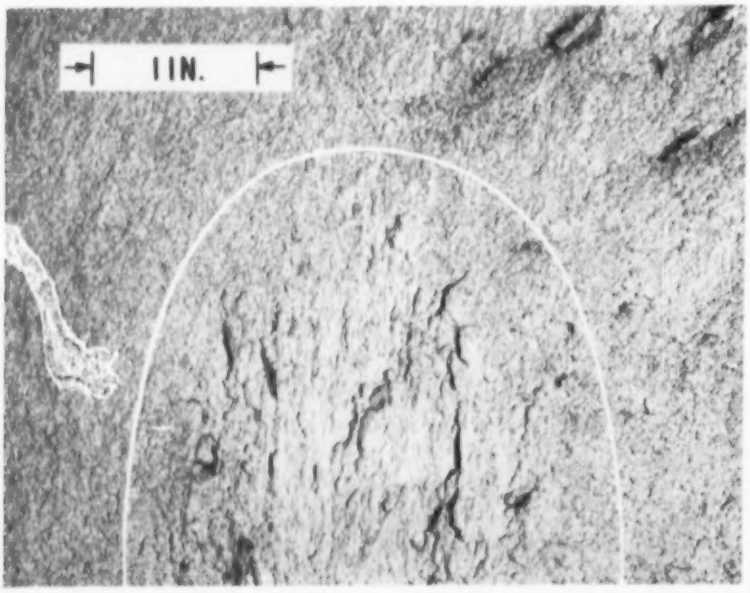


Fig. 3. Close-up photograph showing one portion of the 2-in. x 5-in. woody area

Ultrasonic Testing

Why did the sonic test before service give no indication of anything nearly as large as these inclusions?

In a separate paper† General Electric discussed the abilities and limitations of ultrasonic testing. Both thickness and composition of thin laminar inclusions, it was reported, affect the magnitude of the ultrasonic reflections. These reflections can change with time and/or service conditions, if microseparations are formed. The presence of microseparations associated with an inclusion does not significantly affect the mechanical properties, but drastically affects ultrasonic reflectivities.

Microseparations, which may be thought of as air gaps, need only be in the magnitude of 1/100,000,000 in., to be detected — a virtually molecular separation not even detectable with an ordinary microscope, the resolution of an electron-microscope being required. Perfectly solid non-metallic inclusions, however, must be more than 1/100 in. thick to produce significant ultrasonic reflections.

Therefore the practice of sonic re-examination of large generator rotors after balancing at operating speed and overspeed tests has been initiated. It is believed this will show up large inclusions if they exist. No changes in magnitude of sonic indications have been found to date on 40 rotors General Electric has so examined.

To explore the possibility that there may be other rotors in service

† Ultrasonic Detection of Thin Laminar Inclusions by S. Serabian and C. D. Moriarty.

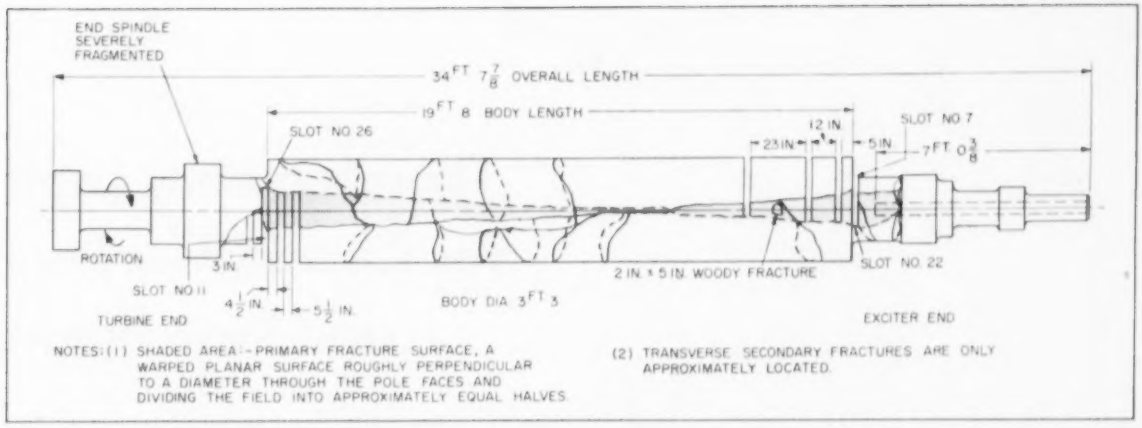

END SPINDLE SEVERELY FRAGMENTED
34FT 7 7/8 OVERALL LENGTH
19FT 8 BODY LENGTH
SLOT NO 26
12 IN
SLOT NO 7
23 IN
5 IN
7FT 0 3/8
ROTATION
3 IN
SLOT NO 11
4 1/2 IN
5 1/2 IN
2 IN. x 5 IN. WOODY FRACTURE
SLOT NO 22
BODY DIA 3FT 3
TURBINE END
EXCITER END
NOTES: (1) SHADED AREA - PRIMARY FRACTURE SURFACE, A WARPED PLANAR SURFACE ROUGHLY PERPENDICULAR TO A DIAMETER THROUGH THE POLE FACES AND DIVIDING THE FIELD INTO APPROXIMATELY EQUAL HALVES.
(2) TRANSVERSE SECONDARY FRACTURES ARE ONLY APPROXIMATELY LOCATED.

Fig. 4. Schematic diagram of burst rotor shows locations of primary longitudinal fracture and major transverse fracture

containing plate-like inclusions covering a relatively large area, approximately 50 generator rotors have been selected for sonic retest at the owner's convenience. It is expected that if there are large planes of inclusions in any of these rotors, they will show as larger indications on sonic retest than they did originally.

Forging Improvement

According to the paper, the results of this investigation re-emphasize the need for improvement of the homogeneity and toughness of large rotors. Work in this direction had been under way for three years since analysis of an earlier burst indicated a need for improvement in three major respects: 1, quality — or freedom from porosity, hydrogen flakes, thermal cracks; 2, homogeneity — or freedom from inclusions, segregations, variations in grain structure; and 3, toughness — or the ability to resist the initiation and propagation of cracks.

Significant progress has been made toward all of these objectives with the able assistance and excellent coöperation of the large forging suppliers.

Discussion

That there is a growing backlog of information on this problem based on case histories became evident during discussion, in which representatives of utilities, generator manufacturers, forging suppliers and instrument companies participated. Most of the results produced by all of these sources corroborated the General Electric paper. Agreement on the relationship of frequency to effectiveness of ultrasonic testing was not achieved, however. While it was agreed that 2.5 mc was more effective under ideal conditions, opinions varied as to whether or not 1 mc was as good under practical — or less than ideal — circumstances.

Mr. Schabtach stated that General Electric will make individual recommendations on the operation of each of their large rotors now in service. Previous to this, utility representatives had expressed concern as to the status of their own large rotors of recent (and varied) origin. THE END

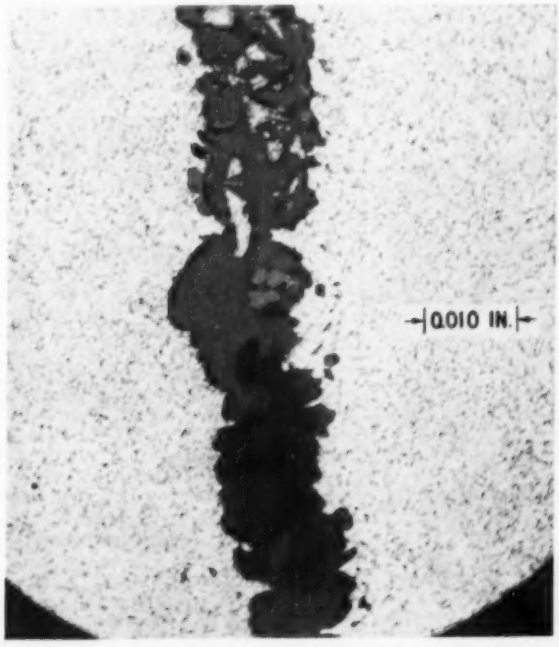


Fig. 5. Photomicrograph of portion of non-metallic inclusion array and surrounding structure in the Pittsburg No. 3 rotor

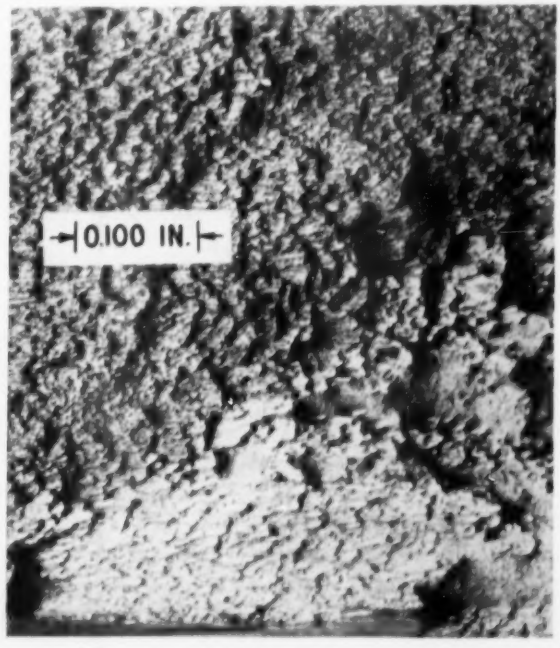


Fig. 6. One portion of fracture surface across the plane of non-metallic inclusions after pulling apart the area at left

There's a New Look for Circuit Breakers and Switchgear

Fig. 1. This new low voltage equipment features first quick-make manual closure, first closed-door drawout both to test and disconnect positions, parts standardization including sub-assembly construction of breakers. Grouping here shows four-high stacking of 600-amp breakers in standard 90-in. high enclosures, made possible by reduction in breaker size

COMPLETELY NEW design in low-voltage circuit breakers and associated switchgear has been announced. The result is a major advance in this type of electrical equipment — in terms of improved performance, greatly simplified operation and servicing, and the most complete standardization in construction and assembly to date in the low voltage power circuit breaker field.

This new line of circuit breakers — 600-v units in 225-, 600-, and 1600-amp frame sizes — is the first to have quick-make manual closure of breaker contacts. As much as one-third smaller and 55 per cent lighter than comparable units, they also have a new motor-driven stored-energy system for electric breaker closure.

New switchgear is the smallest in frontal area yet designed, and introduces the first closed-door draw-out for low voltage power circuit breakers. Breakers can be moved from operating, to test and disconnect positions, within their enclosure without opening switchgear cabinet doors. Reduction in breaker size permits four-high stacking of 600-amp breakers in standard 90-in. high enclosures.

The new breakers and switchgear are designed for commercial building, industrial plant and power station applications — for the switching, control and protection of motors, generators, transformers, feeder circuits and other large electrically-powered equipment.

Manufacturer claims these advantages: 1. quick-make manual closure; 2. motor-driven stored-energy system for electrically-actuated models; 3. greatly reduced size and weight; 4. sub-assembly construction; 5. interchangeable overcurrent trips; 6. automatic trip indicator; 7. pull-down handle which actuates the stored-energy closing system. The handle's design prevents accidental breaker tripping.

Fig. 2. Closed-door drawout is done by turning small crank inserted through lift-shutter opening in breaker front

Fig. 3. Frozen action shots showing operation of pull-down handle to obtain quick-make by storing energy in springs. Bottom, energy is released

Quick-make closure, formerly available only on electrically-operated breakers, now is a standard feature of all manual breakers in the new line. A spring-action mechanism provides the manual quick-make action. It is powerful enough to close the contacts safely against a full short-circuit fault current.

First 90 per cent of travel of the new pull-down handle stores energy in the spring. Only in the last 10 per cent of travel is the stored energy released to close the contacts. Thus, for the first time on manual types, breaker life and operator safety do not depend on the operator's arm and brain.

Electrically-operated models in the new line have, in addition to the basic manually-charged mechanism, an actuating motor. This motor-driven stored-energy system requires only 10 amp from a simple power source, such as an ordinary lighting circuit. Energy for closing is pre-stored; closing time is five cycles.

Four-high stacking of the 600-amp breakers is made possible by one-third reduction in height of this breaker, and the height of the 1600-amp size breaker has been reduced by one-fourth. Compartment width, over the entire line, is said to be less than that of other makes.

Breaker weight also has been reduced; the weight of the 600-amp breaker by 30 per cent, and a 55 per cent reduction in the weight of the 1600-amp size.

For more information on this equipment, write The Editors, POWER ENGINEERING, 308 E. James St., Barrington, Ill., or mark Circuit Breakers on the inquiry card found elsewhere in this issue. THE END

Use Your Operating and Maintenance Manuals

Do you get the manuals you want from the contractor who did your job? Here's an example of a complete manual covering the installation and operation of a 250-ton refrigeration plant

MANUFACTURERS usually furnish many types of drawings and literature with their equipment, the number depending on the complexity of the equipment. This data is given to the purchaser, who is usually the contractor, who is to install the equipment. In many cases, the ultimate owner of the equipment will demand duplicate sets of data at the same time it is furnished to the contractor. This is for the specific purpose of double-checking on space clearances, floor-loadings, conflicts with other equipment, and for assuring the completeness of a file on the equipment being installed.

What happens to all of the installation drawings, erection instructions, operating procedures, start-up instructions, shop drawings, and other valuable information accumulated along the way? The erection drawings went to the man in charge of that phase of the work; and why not? He's the only one who should be interested in such matters. But is he? Of course not; the power engineer who is responsible for operations — after installation — wants to know all about how the equipment went together, for future reference.

What to Include in the Manual

How about the complete parts list or packing slip? This document tells the power engineer just what items constitute a complete installation. Shop drawings — as drawn — and as built, are invaluable documents for the power engineer's files. But what happens to the originals, and where do the field corrections get recorded? It is safe to say that practically every engineer who has gone through an equipment installation project has had to do considerable digging to unearth all the documents which rightfully belong in his permanent files after completion of the job.

One of the best good-will gestures a contractor can make is to assemble a complete set of all papers pertaining to the installation of a piece of equipment, and present it in bound form to the engineer in charge of operations. Some contractors do just this, but many others overlook this important responsibility after the equipment has been accepted by the owner.

Just what constitutes a good operating and maintenance manual? Based on a case involving the installation of a 250-ton refrigeration compressor, in one of New York's most famous buildings, we list the contents of the manual presented to the owner by the installing contractor, at completion of the job. We find these documents between the covers of this invaluable manual:

Schematic piping diagram and valve chart.

Mfgr's. dwg. of system general arrangement.

Mfgr's. dwg. of refrigeration gas piping system.

Mfgr's. dwg. of control board and instrumentation.

Mfgr's. dwg. of special solenoid valve assembly.

Mfgr's. dwg. of schematic control diagram.

Mfgr's. dwg. of water piping to oil coolers.

Mfgr's. dwg. of gear reducer outline.

Mfgr's. dwg. of driving motor diagram.

Mfgr's. dwg. of motor starter.

Mfgr's. dwg. of differential control.

Mfgr's. dwg. of gage and control piping.

Mfgr's. dwg. of freon relief piping and valve.

Mfgr's. dwg. of air piping for automatic operation.

Mfgr's. dwg. of basic electric wiring diagram.

Mfgr's. dwg. of piping and valves for freon purge system.

Complete parts list of items not part of assembled unit. (11 pages)

Manufacturer's service manual (75 pages).

Apparatus bulletin by control instrument manufacturer.

Outline drawing of motor starter.

Wiring diagram of motor starter.

Manufacturer's specifications, operating instructions, outline drawings, etc — covering centrifugal pumps.

Instructions on shaft seal installation and maintenance.

Lubrication instructions.

Recommended minimum spare parts list, as furnished by compressor manufacturer, and requested by owner.

Complete set of "as is" piping drawings.

All of these papers, with the exception of the piping drawings, were neatly bound in a stiff-back binder, and properly labeled. A letter of transmittal accompanied the manual and was bound into it as a permanent reminder. This served to remind the power engineer who the installing contractor was, in case another compressor had to be installed at a later date.

The value of such a manual can be wasted, however, if the power engineer simply gives the book a "once over lightly" — and files it away in some place for safe keeping. The manual serves two important functions: as a record of all the parts constituting the complete installation, and as a set of operating instructions. The power engineer should make certain that all shift operating engineers are fully conversant with operating and maintenance procedures outlined in the manual; otherwise, they cannot be held responsible for equipment failures due to lack of specific instructions. If possible, two complete manuals should be furnished; one for the permanent file in the power engineer's office, and one for the use of the shift engineers.

Make Manuals Complete

Some companies make it mandatory that these manuals be furnished. Too often, however, the individual pieces are furnished spasmodically, as they are received from the various sources. This usually results in a wide distribution — to numerous cubbyholes around the plant, or to the "circular file". The documents contained in a manual of this type are far too valuable to be treated so carelessly.

After receipt of a well-compiled manual, the power engineer can increase its value by adding his own statistical data and cost information. Just a page or two of special notes would help a lot for future reference; such items as detailed cost breakdown, variances from installation standards, dates of installation start and completion, actual refrigerant charge, unusual installation details, and any other pertinent information that might be of value at a later date. All of this will be useful.

Contractors and manufacturers might well take a friendly tip from all this, by following up to see that the power engineer is putting the data to best possible use. A few months after the job has been completed, the owner will have a number of questions, and some complaints, that need attention. A goodwill follow-up call, by both the contractor and the manufacturers, will pay handsome dividends; might also lead to some new business. THE END

Power Engineering handbook

Audigage Tests Metal Thickness Without Drilling

By G. R. SETTERLUND

Fig. 1. Accurate testing can be done from the outside as well as from the inside of a given vessel

A RECENT innovation in methods of measuring is an electronic device known as an "audigage." This device is especially useful in determining degree of erosion in the metal of pressure vessels such as high-pressure air receivers, boiler tubes, air ducts, cooking vessels, and so on. Drilling holes and measuring metal thickness by micrometer or vernier is a slow, sometimes prohibited method. Anything that is insulated or lagged adds to the impracticability of measurement by the straight mechanical methods. But the audigage can easily measure metal thickness under all conditions, to an accuracy of plus or minus 2 to 3 per cent.

The audigage is a compact, battery-operated instrument of about 2 cu ft, weighing around 15 lb. It is quite manageable even in confined areas, as it can be attached by a harness to the body of the operator. It consists of an oscillator which excites a quartz crystal. Here's what happens:

The quartz crystal acts as a probe. A locale is selected on the metal to be measured, and the crystal, coated with grease or glycerine, is held against this position. An aid to the operator is a set of magnets that hold the probe securely

fold along this line—outside edges toward you

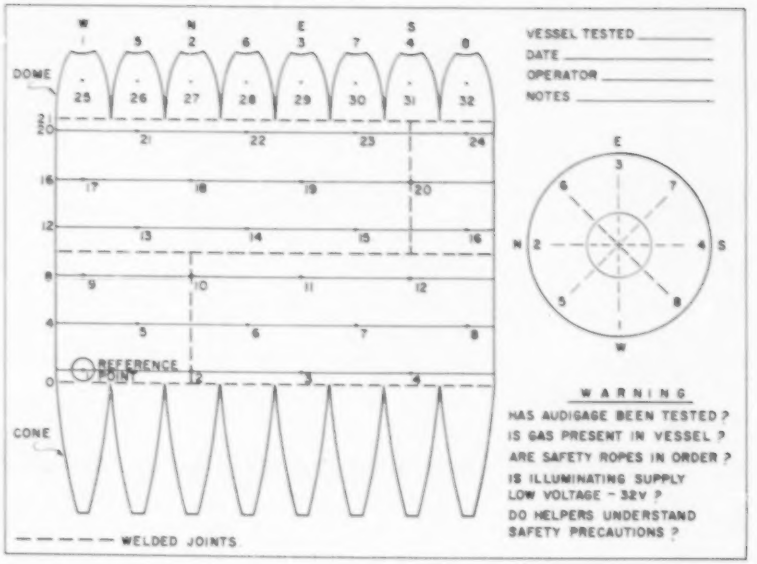


Fig. 2. Any vessel being tested with the audigage should be "rolled out" in single plane drawing, for easy interpretation. Here's the sulphite digester diagrammed for test. The reference point is at lower left

to the metal surface. The rapidly vibrating crystal transmits ultrasonic waves into the metal. The oscillator is now tuned by turning a radio-type knob until the frequency corresponds to the natural frequency of vibrations of the metal. When this coincidence occurs, a visual peak on a milliampere indicator, and an easily distinguished audio signal, are perceived.

When the oscillator tuning scale is swept, two or more signals can be heard. The range between peaks will be proportional to the thickness. Suitable factors can be determined if a sample of the material is tested. Each material has a different factor. By taking the scale differences and multiplying by the known factor, the thickness is found. For example:

A sheet of steel under test showed peaks at 1.88 megacycles and again at 1.48 megacycles. Five evenly spaced intervals were noted between these two figures. Since 1.88 minus 1.48 equals a 0.40-megacycle difference, and dividing by the five peaks, an interval or frequency difference of 0.080 is found. Using a factor of 0.116 (for the type of steel under test), the thickness then would be 0.116 divided by 0.080 or 1.45 in. Test after test has proved an accuracy of 3 per cent over any range.

Divide the Job

Suppose the job at hand is to check a sulphite digester. This is not the first time, and past records indicate that metal is disappearing. By repeated checking a determination will be made of the rate of loss, and research should indicate steps to prevent this loss.

Before testing, the audigage must be checked for calibration. A predetermined piece of metal is measured and the audigage is "proved." If not correct, an adjustment is made to assure that it is correct.

A plan drawing of the digester has been made (Fig. 2) showing seams, liquor

cut along this line

wherever you are,

the answer to your plant water problems

is . . .

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

BETZ LABORATORIES INC., Philadelphia 24, Pa.

inlet pipes, recirculation pipes, etc, so that orientation inside the vessel will be less difficult. Any vessel being tested should be "rolled out" in a single plane drawing, for easier interpretation.

The mechanic may want to take a few sheets of dental wax with him, to make impressions of some particularly badly corroded spot or some noticeably odd formation; or a flash bulb and camera will do more for the record than a thousand words. So, armed with a calibrated instrument and the other paraphernalia, the mechanic descends into the empty digester.

A thorough visual examination is made and notes are taken on the entire area up to about eight feet. Depending on necessity, the lowest spots are selected for measuring. As tests have been made before in this vessel, the same spots are located, using a known reference point. The reference point in this case is point 1, west of the north vertical seam, first course, and one foot up from the cone seam (Fig. 2).

Having descended into the digester on a steel ladder, securely encircled with a stout rope for safety's sake, the mechanic has had time to assure himself that the vessel is free from gas. A small fan at the top manhole keeps a fresh air supply coming in constantly. Now the rope can be removed. The carrying harness is donned, the audigage secured, turned on for a brief warm-up, and the crystal greased. Carefully placing the crystal against the wall of the digester, the testing is started.

The tuning dial is swept across the scale, the volume adjusted to suit local noise conditions, until a peak is found. This peak reading is recorded. The sweep is now continued and the peaks are counted. The rule is to find as many as possible and then record the last one. Conversion of the average difference into a thickness reading, as explained above, completes test spot No. 1.

The process is continued until all the spots within reach have been checked. Any new spots noticed are measured and recorded, with their location accurately defined for future reference.

The mechanic can now climb out for a breath of air, while a helper fills in the digester with chips to a suitable height to take the next measurements. This procedure is repeated until the testing is completed. The whole job should take about two hours, which would probably be about the time required to drill one test hole. With the audigage, some 32 locations have been tested in this time.

Graphs and drawings portraying the exact condition of the vessel after each test will tell a definite story of what is happening to the metal. If it is not possible to enter the vessel, the same accurate results can be obtained from the outside. Pipelines can be measured readily. Even small pipes can be handled, by using concave-shaped crystals.

For more information about the audigage, write The Editor, POWER ENGINEERING.

Question About Pumps

Answered by IGOR J. KARASSIK, of the Worthington Corp

QUESTION: Our boiler feed pumps have a forced feed lubrication system. There is a small hand oil pump located within this system. What is the purpose of this pump and does its presence indicate that the pumps cannot be started by remote control?

ANSWER: The purpose of a hand oil pump in such a lubrication system is to clear the air pockets in the oil system and to insure that the oil is ready to flow to all the bearings. Actually, the hand oil pump need only be used at the time of the initial filling or after the oil system has been drained or dismantled.

If a pump stays idle for a long period of time, it is recommended that this hand pump be used once a week. This will take care of any evaporation and will remove any sluggishness of the oil system on a new start-up.

If a standby pump is turned over once a week, as is the case in many steam power plants, the use of the hand oil pump is not required except when the lubrication system has been dismantled or the oil changed. There is sufficient oil trapped in the bearings to take care of all starting requirements.

Therefore, if standby pumps are run once a week, or if the hand oil pump is used once a week on idle pumps, there is absolutely no reason why the boiler feed pumps cannot be started by remote control.

fold along this line—outside edges toward you

Believe It Or Not —

Steel Pen Works As Oil Atomizer

By EDWARD F. HATHAWAY

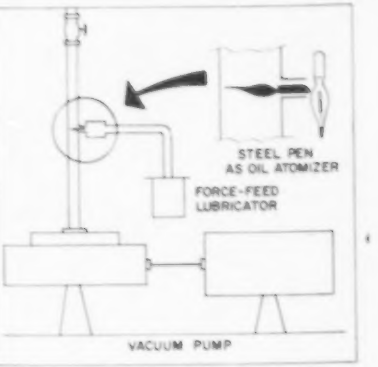
HERE'S A STUNT that looks as though it came right out of Ripley; but it actually happened in our plant.

We have a single cylinder pump exhausting a condenser for a double-effect evaporator. Due to a poor hook-up, the pump gets very wet steam when starting up. The oil line from the force-feed lubricator runs to a tee in the steam pipe, and even with a heavy feed valve would run dry and the pump would hang up on the ends of the strokes.

While looking for a $\frac{1}{8}$-in. tube (which I didn't have) I happened to notice my pen lying on the desk. The point has a bowl with a slot in it just below the point; also, the shank just fit the hole in the oil pipe. It looked worth a try, so I inserted it as shown in the sketch.

So far, after four months of use, it has worked very well and shows little change from original condition. Of course, it was not intended as a permanent solution, but I believe the cylinder oil is going to keep rust off, and steam velocity is not high enough to do any damage.

The idea certainly helped me out of a bad situation.



Steel pen point as oil atomizer has worked 4 months

Portable Electric Equipment Properly Grounded?

IF PORTABLE ELECTRIC equipment is not properly grounded, burns and death-causing shock may result, the National Safety Council forcefully points out.

Indirect injuries, too, may arise.

To reduce the danger of electrical shock, it is important that a separate ground wire be provided from the tool to a low-resistance ground connection. Water pipes, metal frameworks of buildings, or other metal structures in direct contact with the earth, may be used to ground equipment.

Here are some suggestions on grounding portable electrical equipment:

1. When wiring is enclosed with metal conduit or protected by armored cable, all couplings and fittings used to make connections between the conduit or cable and the electrical equipment should provide metal-to-metal contact to assure a continuous ground return.

2. If the wiring is non-metallic sheathed cable or knob and tube work — such as is used in construction work — a third wire must be connected to the grounding terminal on the receptacle to provide a good conducting path to a grounding electrode or water pipe.

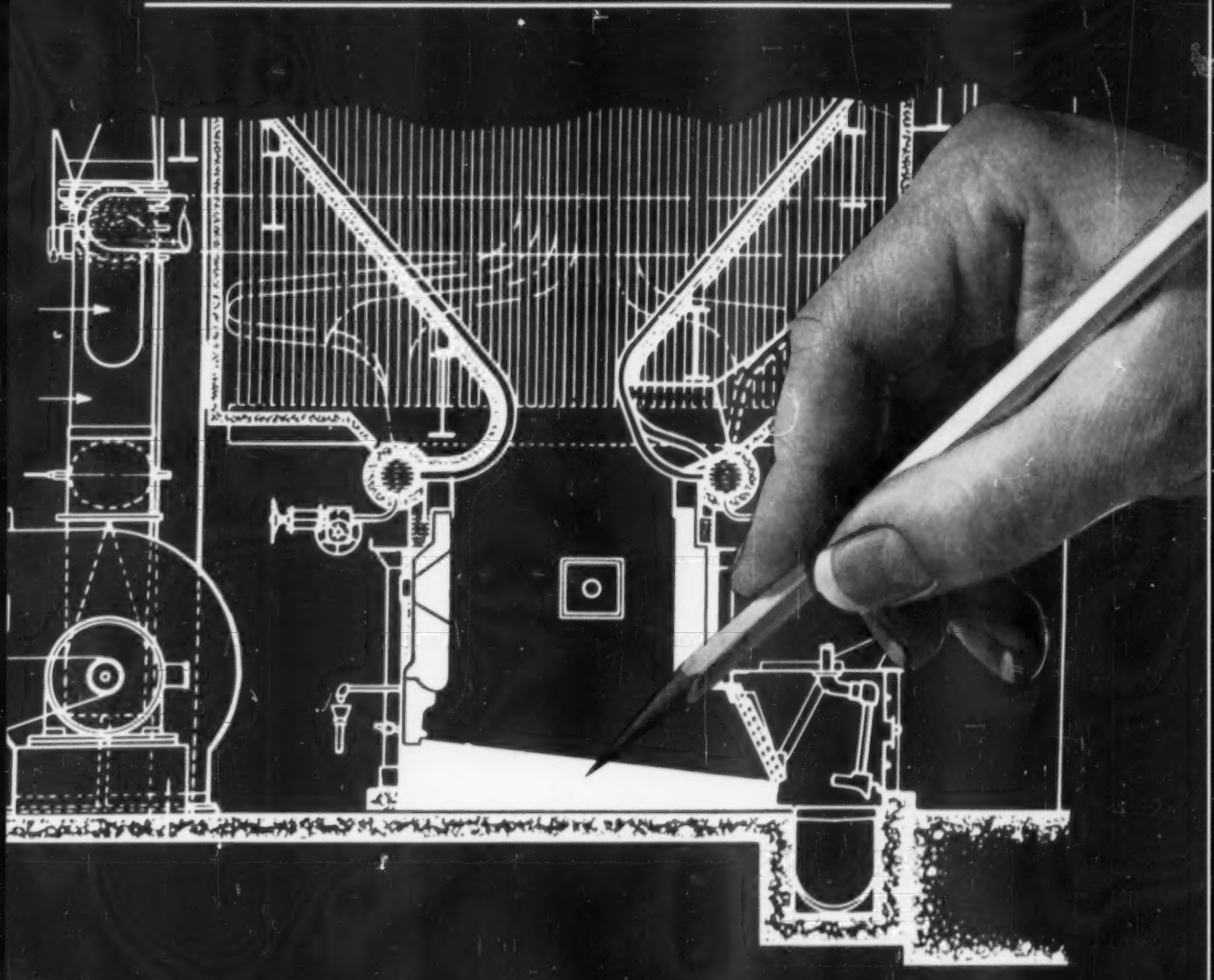
3. Grounding wires should be checked to see that the size is correct for the capacity of the nearest fuse or other automatic cut-out.

4. No fuses, automatic cut-outs or hand-operated switches should be inserted in a grounding line.

To ensure automatic use of the ground, a common type of plug with a U-shaped grounding blade and two standard parallel polarized blades now can be used.

cut along this line

How to draw the line on ashpit maintenance



"Let's put Kaocrete here"

Relining ashpits is expensive and time-consuming. That's why more and more utilities and industrial companies are specifying a heavy-duty refractory castable such as B&W Kaocrete D. On job after job, it has withstood the heavy abrasive or erosive attack of sprays, jets, rakes or shovels.

The reason? Specially designed Kaocrete D has the strength and hardness needed for tough ashpit service. It has unusually high resistance to abrasion, erosion and spalling. It saves time because it can be poured or gunned into place. For less severe abrasive or erosive conditions, B&W recommends Kaocrete A.

Get the facts and figures on these B&W Refractory Castables from your local B&W Refractories Engineer.

Send for Bulletin R-40 which gives data on B&W Kaocrete Refractory Castables for lining ashpits.

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R-549

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Fig. 1. Indicator developed at Detroit Edison measures differential expansion of rotor, casing

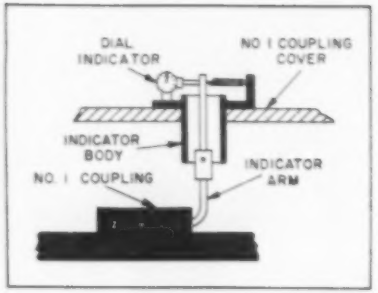

Fig. 2. Schematic diagram of device to measure expansion of rotor. Spring for arm is not shown

Easy-To-Make Device Measures Turbine Stretch

ONE OF THE limiting factors in quick start-up of turbines is the differential expansion that occurs between the casing and rotor.

When load is applied to a turbine, the casing and rotor absorb heat and begin to expand, but the rate of expansion of these two parts is not the same — one expands faster than the other. It is this difference in movement along the axis of the turbine that is called differential expansion; it must not exceed the limits specified by the manufacturer or the turbine will be damaged by the rubbing that will occur between stationary and moving parts.

Modern turbines are equipped with instrumentation to measure differential expansion during start-up; also, instruments are available for older units but these are expensive and complicated to install.

The production and engineering departments of the Detroit Edison Co recently came up with a simple, inexpensive device to measure differential expansion on some of their older turbines; this instrument was described in *Coal to Kilowatts*, the company's employee publication.

Essentially, the device consists of three parts: body, indicating arm, and dial indicator (see Fig. 2). Lower end of the arm rides against the flange face of a shaft coupling; a spring holds the arm against the flange when readings are taken.

Any axial movement of the rotor which is caused by differential expansion is transmitted to the dial indicator which is placed against the upper end of the indicator arm.

Indicator was mounted in the coupling cover at the No. 1 coupling because this location was relatively cool and practically no casing movement takes place there. With the indicator located at this point, it is not necessary to correct readings for casing movement — any movement shown by the indicator is the differential expansion between the rotor and shell (Fig. 3).

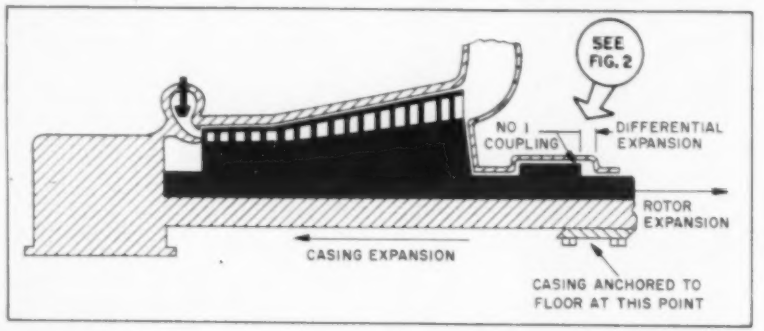

Fig. 3. This diagram shows location of differential expansion measuring device on casing of coupling

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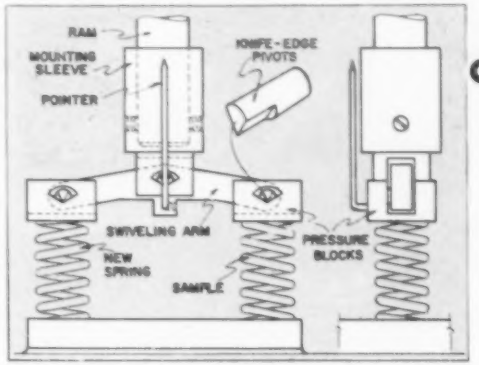

Attachment for measuring stiffness of compared springs is locked to ram of small mandrel press

Attachment for Comparing Springs

By F. E. RILEY

IN SOME TYPES of engine repair work it is necessary to make replacement springs which will deflect through the same distance as a sample under a similar load. A simple attachment for fitting to an ordinary small mandrel press has proved effective for this job of comparing springs.

The sample spring and the new spring are placed on the work plate of the mandrel press under the pressure blocks placed on the ends of the swiveling arm.

Knife-edge bearings are provided for both the pressure blocks and the central pivot of the swiveling arm and are made from pieces of round drill rod in the manner shown in the drawing. For sensitivity under small loads, the arm and the pressure blocks are made from a tough aluminum alloy.

The attachment is locked to the cylindrical ram of the mandrel press by two set screws which engage with tapped holes in the mounting sleeve and bear on the press ram. The mounting sleeve is integral with the central bearing for the swiveling arm.

When the two springs are of equal stiffness and length, the extended pointer will be centrally disposed in relation to a datum line engraved on the exterior of the mounting sleeve, after downward pressure has been applied to the press ram. Variations in the stiffness of the two springs will be indicated by the off-center deflection of the pointer. The weaker spring will compress through a greater distance than the stronger spring and this will be indicated by the pointer deflecting towards it.

This attachment gives no indication of the pressure needed to compress a spring through a certain distance, but it is very useful for comparing springs with samples which are known to be correct for the job.

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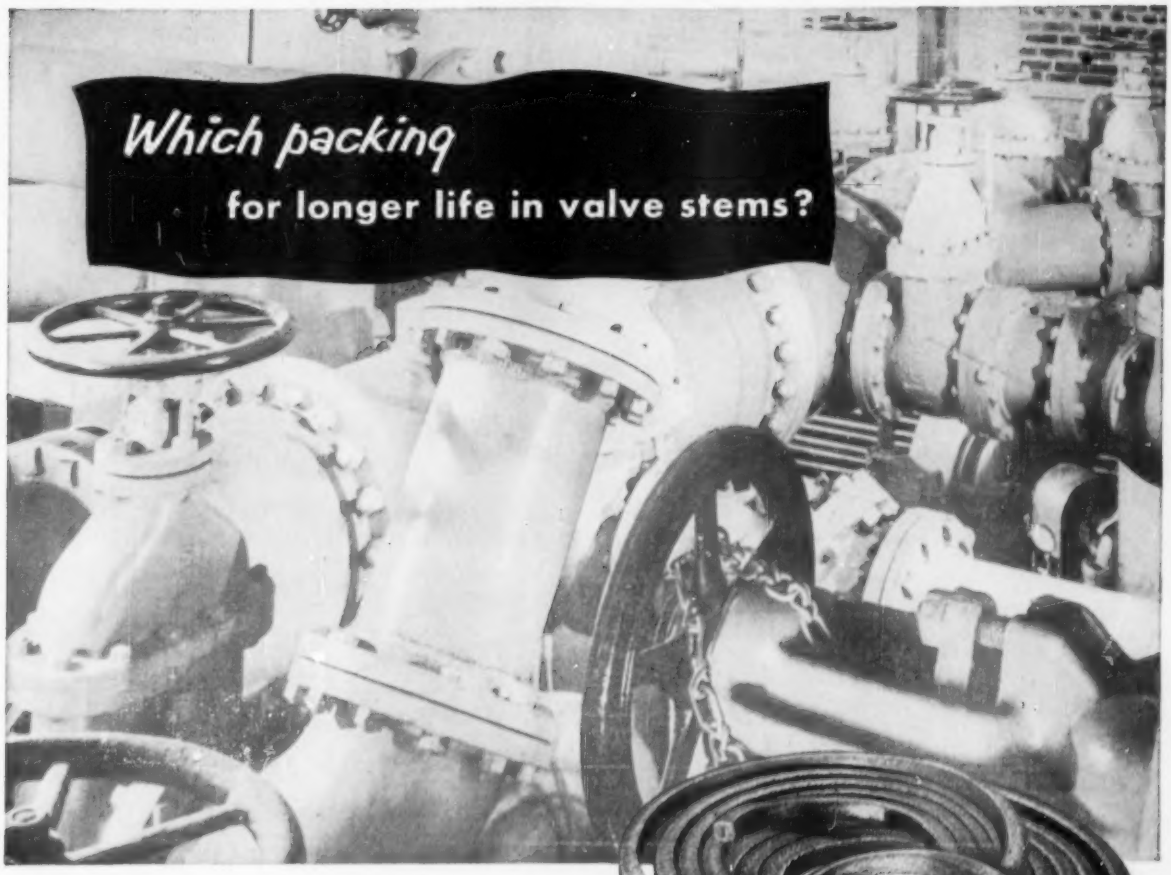

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To obtain this high sealing efficiency, Johns-Manville braids asbestos yarn of high purity over a plastic core of special heat resistant composition. For extra strength, the yarn is reinforced with tough heat and corrosion resistant Inconel wire. The packing is formed square and then lubricated with graphite. Furnished in ring, coil and spiral form in sizes ¼″ to 1″.

Your local J-M distributor carries full stocks of Jewett, High Temperature and other packings. Call him today or write Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

Johns-Manville PACKINGS, GASKETS and TEXTILES

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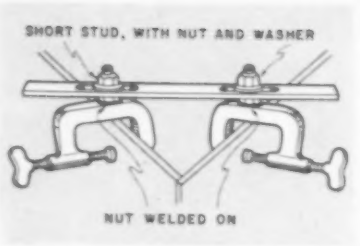


Fig. 1. C-clamp rig for positioning various jobs

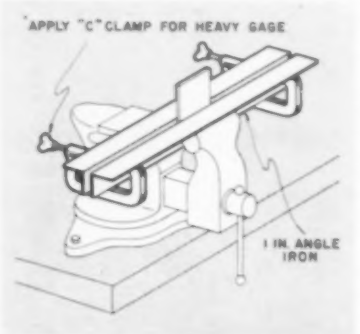


Fig. 2. Two pieces of angle iron can be used for gripping wide work on thin or heavy gage material

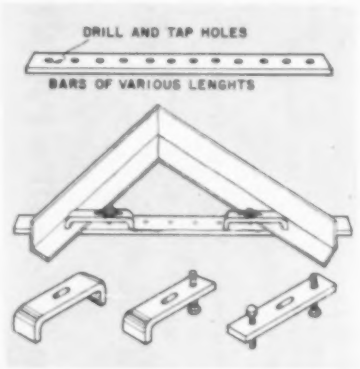


Fig. 3. Bar clamps like these can be made up to position work for welding, soldering, drilling

Good Bench-Work Ideas

By CHARLES H. WILLEY

FIGURE 1 shows a way to make C clamps more useful. Take steel hexagonal nuts of suitable size and weld one on each clamp, midway on the back, as shown in the sketch. Use a short stud, a nut and a washer, make a slotted rectangular bar, and you have a universal clamping rig. This will hold in position various jobs of assembly, welding, and the like.

A couple of short lengths of angle iron, used as shown in Fig. 2, come in mighty handy for gripping wide work on thin material when bending, sawing or filing. If the work seems too heavy for the angle iron to grip by the vise jaws alone, use C clamps at the ends.

We have made up several pairs of bar clamps as shown in Fig. 3, and use them effectively to position work for welding, soldering, brazing, drilling, assembling, even as temporary braces. Their potential use is extensive. Make the bar section of good steel flat-bar stock, of suitable width and thickness for your work. Make several pairs and lengths; drill and tap holes in the bars at spaced intervals,

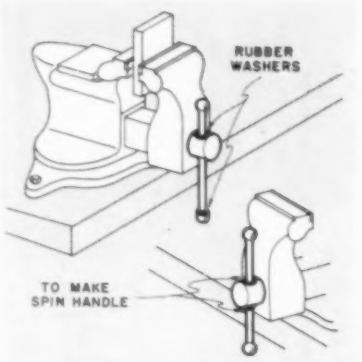
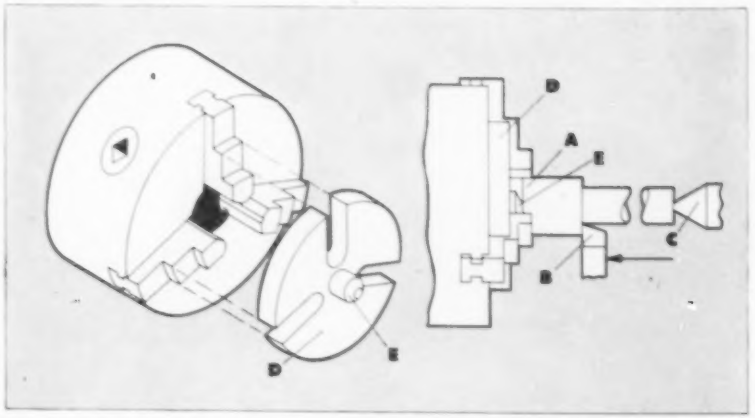


Fig. 4. Rubber washers will prevent pinching on handle of bench vise, also will make spin handle

fold along this line—outside edges toward you

to make the sort of strap you want.

Anybody who has ever pinched his flesh while operating the handle of a bench vise, will want to prevent it in the future by the simple trick of putting two washers on the rod handle, as shown in Fig. 4. These will also serve to make a spin handle when the washers are slid to the center, as shown, and wide openings or closing can be accomplished with a spin. Just make the washer center hole about half the diameter of the rod so that it will grip tight. An old inner tube will furnish the rubber.



Disk D has three equally spaced radial slots which fit the chuck jaw thickness. E is detachable shouldered plug of any desired length. A is gripped end of work, B is cutting tool, and C is the tailstock center

Chucked Work End Stop

By JOHN J. O'BRIEN

TO AVOID centering both ends of shafts for turning in the lathe, it is usual to grip them at one end in the self-centering chuck and to support the outer end with a tailstock center. The gripped end, A, as shown in the figure, should be short so that the maximum length of the work can be turned. If a deep roughing cut is taken by the tool, B, the feed forces the work further into the chuck jaws and out of engagement with the tailstock center, C.

A form of positive stop for the chucked end of the work has been evolved and is suitable for a range of shaft diameters. The stop comprises a disk, D, with three equally spaced radial slots which are a running fit to the chuck jaw thickness. The center of the disk is fitted with a detachable shouldered plug, E. The plug can be of any desired length to control the length of grip of the chuck jaws and has an end of truncated conical form. The small diameter of the flattened end of the cone presents a small area to the shaft end which can be rough sawn. A large area would affect the end location of the work if the shaft ends were cut off at an angle.

By virtue of the slots fitting on the jaw thickness, the disk is self-centering and the jaws can be adjusted to any convenient diameter without interference from the disk. The disk eliminates the dangerous practice of inserting flat pieces of steel between the shaft end and the face of the chuck body. Such temporary stops fly out and cause injury.

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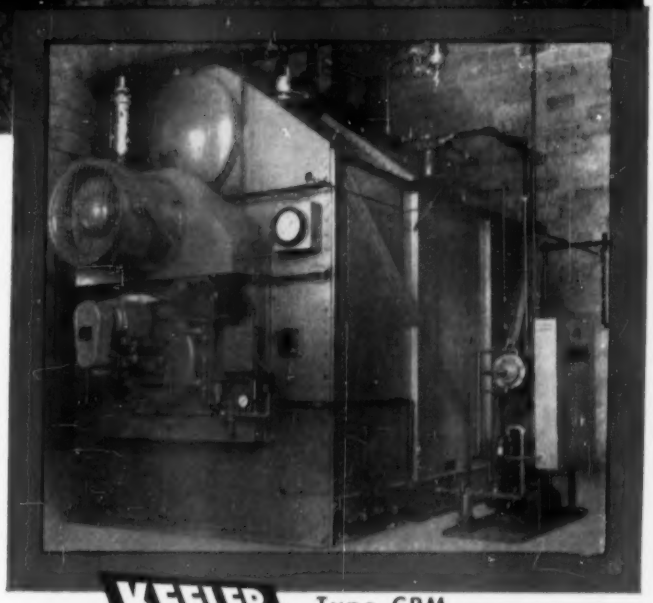
Photo above shows a shipment of four Keeler Type CPM steam generators leaving the factory for quick hook-up in a railroad shop installation.

KEELER CPM tube spacing provides full heat transfer



KEELER Type CPM

A modification of the CP for gaseous and liquid fuels use. An economical forced draft, pressurized furnace unit complete with burning equipment and accessories attached. Pressures to 500 psi, steam capacities to 34,000-lbs. per hour.

The KEELER CPM STEAM GENERATOR is a modification of the popular CP Boiler in the package field, developed with a pressurized furnace for forced draft operations.

Typical of this package steam generator's features is the "staggered tube spacing" illustrated above, with water tubes positioned at right angles to the gas flow. Full heat transfer is assured with this arrangement—the gases or products of combustion completely envelope the tubes as they travel from furnace to outlet. Wide and narrow spacing in the tube bank is another CPM feature—permitting quick replacement of any tube, when necessary, without disturbing any other tube.

The KEELER CPM is an economical package steam generator, completely steel encased and insulated, with water cooled furnace. Write for illustrated bulletin containing full specifications.

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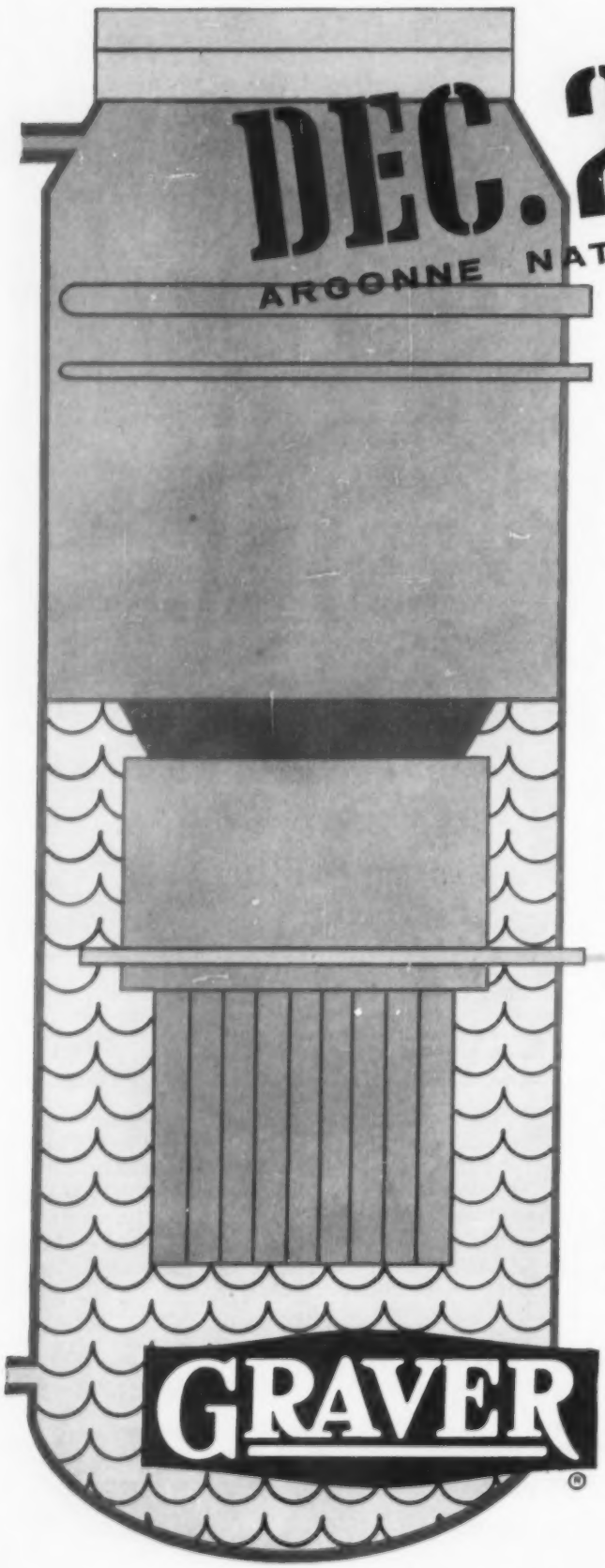

A date long to be remembered as a milestone in our expanding nuclear technology. On this day, after many months of scientific investigation, planning and construction, the Experimental Boiling Water Reactor reached full power generation.

This reactor, dedicated to the peace and prosperity of mankind, employs a promising new system for the generation of power from nuclear fuels. Operating on a direct steam cycle, it eliminates the need for intermediate heat exchangers and permits operation of the reactor at a pressure no higher than that required for the turbine generator system.

The primary advantage of this "direct-boiling" reactor is the simplicity of the reactor itself and associated power system. In the simplest terms, the reactor is operating as a boiler. Nuclear energy liberated by a chain reaction heats the uranium metal fuel plates, which, in turn, transfer the heat to the water around them. This is diagrammatically shown in the sketch at left. Part of the steam produced, at the proper pressure, is used for the generation of electricity.

The continuous removal of corrosion products from the water in the reactor vessel is the function of the reactor purification system. This all-stainless steel system removes water from the bottom of the reactor and, after cooling, delivers it to the ion exchange columns. The resin exchange beds remove all ionic impurities. Purified water is then pumped back with the feedwater. This ion exchange system consists of two Graver rubber-lined, mixed-bed units, 20" dia. x 84" high, having four inches of lead shielding and weighing about 18,000 pounds each.

Graver also furnished a second separate ion exchange, or demineralizing, system for the treatment of makeup water. That system has two rubber-lined, mixed-bed units, 24" dia. x 9'0" high, and a complete regeneration arrangement.

Although only a small part of an important project, both of these systems had to meet the extremely high requirements of engineering, construction and performance required in all Atomic Energy work — another example of Graver's high engineering standards for water treatment equipment.

Industrial Department: I-311

GRAVER WATER CONDITIONING CO.

Division of Graver Tank & Mfg. Co., Inc.

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ATOMICS

A section of POWER ENGINEERING covering current and forthcoming developments in the field of Nuclear Power throughout the world

ANDREW W. KRAMER
Editor

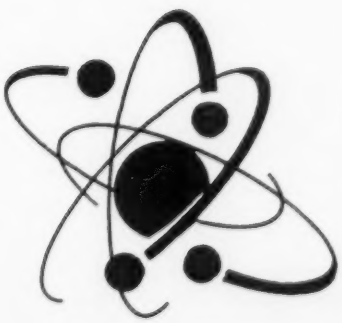
This 12-page ATOMICS section has a long and interesting history. Without doubt, ATOMICS is the oldest publication in the field of nuclear energy because, in one form or another, it has been published continuously since September 1945. As far as we know it antedates all other atomic publications.

The news of the explosion of the atomic bomb over Hiroshima rocked the world on August 5, 1945. Less than a month later, in the September 1945 issue of POWER ENGINEERING, we published a 12-page special section containing three articles giving a preliminary explanation of this strange new force. First, there was an article entitled, "Atomic Energy is Here," a very brief history of the development of the atomic bomb. A second article under the title of "Uranium and Atomic Energy" reviewed the history of atomic research and presented a detailed description of the fission of uranium. Finally, there was an article by Edward U. Condon on "Atomic Bombs and the Future."

By the time the next issue of POWER ENGINEERING went to press, the famous Smyth Report had been released and based on the information in that report we presented the first of a series of five articles on the theory and development of the atomic bomb and the possible application of nuclear energy in the field of power generation. All of this material appeared in consecutive issues under the general heading of ATOMICS and was later reprinted as a 32-page booklet.

From that time to the present, ATOMICS has been published regularly either as a section in POWER ENGINEERING or as a separate publication. Until May 1949 it ran as a special section in POWER ENGINEERING. Then, it was removed and published as a separate 32-page magazine devoted not only to nuclear power but to all other aspects of nuclear science as well. More recently ATOMICS has been published as a technical letter for engineers in industry.

During the 12 years since Hiroshima, POWER ENGINEERING has published material on virtually every aspect of nuclear energy from basic nuclear theory to detailed descriptions of nuclear power plants. The Editor has had a long and close association with every phase of nuclear research and development. In 1946 he was a member of the Bikini expedition to report on the first atomic bomb tests in the Pacific, and since 1951 he has been a member of the Advisory Committee on Industrial Information of the AEC. His thorough knowledge of this field has been reflected in his many articles.



Nuclear power is now entering the first stages of practical development. In this country, Shippingport Station is scheduled to go into operation early next year. In Great Britain where the fuel situation is much more critical, Calder Hall Station has been in service for over a year and, as indicated by the article on Dounreay in the November issue of POWER ENGINEERING, the world's first large fast reactor will be completed in the north of Scotland, late in 1958. On the continent, several European nations have plans for nuclear power plants in progress.

Because of this steadily increasing practical use of nuclear energy throughout the world we have decided to re-establish ATOMICS as a section in POWER ENGINEERING. It will appear in every other issue and, it will endeavor to cover all aspects of nuclear development in language that practical engineers can understand. We sincerely hope that you will find it of interest.

Fig. 1. Aerial view of the Engineering Test Reactor buildings and the general area at the National Reactor Testing Station

ETR—AEC's Newest Test Reactor

The new $14,000,000 Engineering Test Reactor at the Idaho Testing Station of the Atomic Energy Commission has the highest power rating and heat flux of any test reactor in the world. It has many novel features, including black and grey bottom-driven control rods and the use of boron poison in the fuel to minimize reactivity changes

ONE OF THE outstanding events in the field of atomic energy in the United States during the past year occurred on May 20, when the new Engineering Test Reactor went critical at the Atomic Energy Commission's National Reactor Testing Station in Arco, Idaho. The completion of this $14,000,000 facility, the newest member of the family of reactors at the vast Idaho Testing Station, is considered a major breakthrough in the AEC's program to advance construction of nuclear power plants for civilian and industrial use. It not only more than doubles the high-flux space available for tests of reactor components but it provides the highest average (neutron) flux available for materials testing of any reactor in the world. It provides the largest volume of experimental holes within its core for exposure of future reactor components to neutron radiation. ETR is rated at 175 mw and it has an average thermal neutron flux of 4×10^{14} neutrons per cm^2 per sec. and an average fast neutron flux of 1.5×10^{15} n/cm^2 sec. These values give ETR the highest power rating and heat flux of any test reactor in the world. Also, it is the only reactor with in-pile holes larger than 3 in. by 3 in.

Why Test Reactors?

Now why is this test reactor so important? As is well known the AEC has had a Materials Testing Reactor (MTR) in operation for about five years, and this has been used to study the effects of intense nuclear radiation on materials of various kinds. So, just how does this new Engineering Test Reactor differ from the Materials Testing Reactor?

In general terms, the difference is that the materials testing reactor is more suitable for tests on small samples of materials and for experiments which fall in the research classification while the engineering test reactor is able to irradiate much larger quantities of materials and is more suitable for experiments designed to provide engineering information and performance data. Test reactors are needed in order to determine in advance of their actual use in power reactors the effects which nuclear radiations would have upon various reactor materials, fuels, coolants, and components. They provide intense sources of neutrons and gamma radiations in which to irradiate materials. They provide regions in which high energy neutrons predominate, other regions in which the neutrons have been slowed down to thermal energies and still others in which intermediate energy neutrons predominate.

Thus, effects which are peculiar to the energy of the neutrons may be studied by placing the materials in the appropriate region. Not the least important is the ability of test reactors to provide environments which are at least equal in severity to, and often more severe, than those which are expected in the power reactor for which the material being tested is to become a part. This is done by placing samples to be tested in a tube which passes through the test reactor core. This tube, generally known as a loop, has its ends connected through piping to the region exterior to the test reactor tank. Provision is then made to circulate through the loop the same coolant which would be used in the power reactor and to operate at the same temperature and pressure as in the power reactor.

It is sometimes suggested that power reactors might be used for irradiation testing, thus reducing the

need to build test reactors. This, however, is not an acceptable alternative. Power reactors will not provide the versatility which is needed for test purposes. They are designed to provide firm power, and deviations from the operating pattern to favor an experimental irradiation are not likely to be welcomed. It is clear that these needs have to be met by reactors specifically designed for testing.

Dr. Kenneth Davis, Director of Reactor Development of the U. S. Atomic Energy Commission estimates that between now and 1980 there will be installed in the United States, a total of some 227 million kilowatts of power reactor capacity. If one assumes the average electrical capacity of reactors involved in these installations to be 100 mw, the number of reactors to be installed in each five-year period would be as follows:

Period	No. of 100-mw Reactors Installed During Period
1956–60	8
1961–65	42
1966–70	186
1971–75	663
1976–80	1373
	Total 2272 × 100 = 227,200 mw

To meet the demands of these power reactor growth predictions, Dr. Davis estimates that the United States will need the following number of test reactors:

Period	Total Number Test Reactors
1956–60	2
1961–65	7
1966–70	12
1971–75	15
1976–80	17
Total	53

This table makes allowance for decreased testing requirements due to duplication of reactor types and increased technical knowledge.

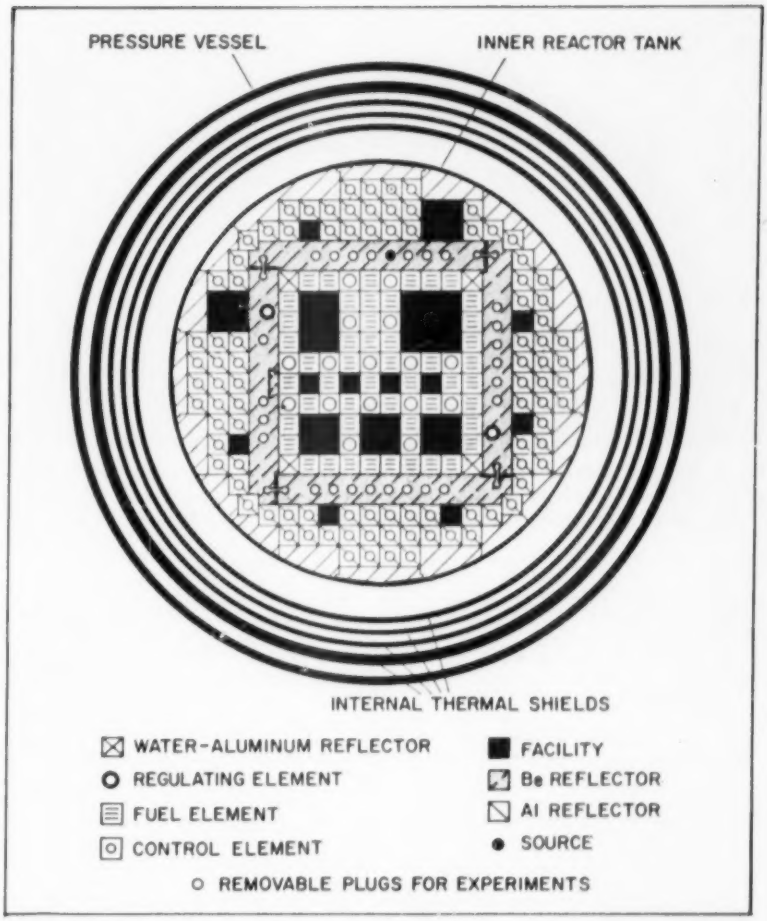


Fig. 2. Plan schematic of ETR. Core facilities include one 9 by 9-in. hole, one 6 by 6-in. and four 3 by 3-in. holes. In the reflector are two 6 by 6-in. holes and six 3 by 3-in. plus numerous basket holes. These test holes are all surrounded by fuel

Engineering Test Reactor

The Engineering Test Reactor is a very highly developed device. It incorporates every recent advance in the test reactor art and represents a considerable improvement over its predecessor, MTR, built only five years earlier. Much was learned from the operation of MTR and we can assume that we will learn in a similar fashion from the operation of the ETR. It also will represent a step in the evolution of test reactor design and will be followed in the years to come by still more advanced units.

ETR is unique in that it contains within the core region a very large number of experimental facilities. This point is illustrated in Fig. 2 which shows a cross section of the reactor through the pressure vessel. Starting in the central region is the reactor core with the 49 fuel elements marked with parallel horizontal lines, the 16 control elements designated by circles and the experimental facilities shown as black areas. The reactor core occupies a matrix of 100 3 in. by 3 in. squares and, of these, the experimental facilities occupy 31 positions.

As shown, these facilities consist of three 6 in. by 6 in. experimental holes, four 3 in. by 3 in. holes, one 6 in. by 9 in. facility and one 9 in. by 9 in. experimental region. Each of these facilities is surrounded by fuel and all except two of the 3 in. by 3 in. facilities are through holes. This means that an experiment enclosed in a pipe may enter the pressure vessel above the core, go completely through one of the experimental holes, come out under the grid plate which supports the core and leave the pressure vessel at the bottom. Thus, it is possible to arrange experiments in the form of self-contained loops which pass completely through the reactor core region and which may contain such components as flow meters, pumps and heat exchangers.

Outside the core region and surrounding it is a slab of beryllium reflector which contains additional experimental holes into which capsules containing materials may be placed. The reflector also contains two regulating rods shown as black circles. One of these rods acts as a spare so that only one regulating rod is used at a time.

The whole assembly just described is contained within the inner reactor tank with the space between the tank and the aluminum reflector pieces filled with aluminum *filler* pieces. Cooling water is made to flow through the core, beryllium and aluminum reflector pieces and back up through the internal thermal shields located between the inner reactor tank and the pressure vessel.

It would be desirable if the pressure vessel could be made the same size as the inner reactor tank. However, at the normal power level of 175 mw of heat generation in the fuel section, an extremely high flux of gamma radiation is produced and this causes a very high rate of heat generation in materials placed near the core. In order to reduce the resulting thermal stress in the pressure vessel, the pressure vessel is made considerably larger than the inner reactor tank. The space between the pressure vessel and the inner reactor tank is

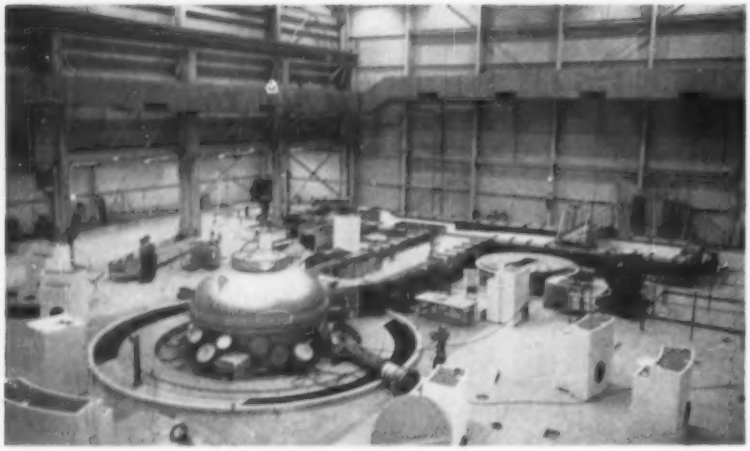


Fig. 3. General interior view of the ETR looking down on the reactor floor. Top plug of the reactor is in place. The plate type covers are in place over the experimental access holes. The white blocks on floor are removable concrete shields

filled with *thermal shields* consisting of layers of steel and water. The thermal shields reduce the gamma flux incident on the pressure vessel to a tolerable value.

Control System

The Engineering Test Reactor has a control system which relies upon 16 control rods and a regulating rod. Four of the control rods are conventional, thermally black, poison rods, i.e., essentially all thermal neutrons which strike them are absorbed. It is expected that during normal operation, these four black safety rods will be out of the core and will be used only in the event that a scram occurs or a shutdown is desired. Operational shim control of the reactor is accomplished through the use of the remaining 12 *grey* rods. The grey rods are designed so that the absorption and scattering cross sections approximate closely the absorption and scattering cross sections in a normal fuel rod. However, there is no fissionable material in the poison section of the grey rods. Thus, the major effect of a grey rod insertion is to remove the source of fission neutrons. However, because of the large diffusion length of fast neutrons, the neutron flux distribution is not perturbed severely as would be the case if a black control rod were used. The grey rods, therefore, are designed to meet the objective of minimum distortion of flux near experimental facilities.

The grey rods are, of course, not as strong in terms of reactivity effect as the black rods. Twelve grey rods have a strength of approximately 12 per cent, whereas the four black rods control about 13½ per cent in reactivity.

In addition to the grey and black rods, the ETR also utilizes a regulating rod. This is a circular rod approximately 1¾ in. in diameter and made of stainless steel containing boron. The regulating rod is located in the reflector region and is designed to have an effectiveness of about 0.3 per cent in reactivity. It is driven by a servo system so as to compensate for small changes in the reactor and keep the power level constant.

An interesting feature of ETR is the use of burnable poisons in the fuel. The fuel elements are flat plate aluminum-uranium assemblies similar in construction to the fuel elements of MTR. They are 36 in. long and contain approximately 255 gm of uranium-235 together with 1.55 gm of burnable poison — elemental boron. Each element has 19 — 0.05 in. thick 2.626-in. wide flat plates that are brazed into aluminum side plates so as to form a 3 by 3 in. assembly. Each fuel plate consists of a homogeneous enriched-uranium-alloy core, 0.02 in. thick, completely clad with a 0.015 in. layer of aluminum. The burnable poison is contained in the cladding. The cladding is bonded to the uranium core by a hot-rolling process to insure adequate contact between the two parts.

The operation of the burnable poison is simple in concept. At the start of the operating cycle, the boron in the core is a parasitic absorber which decreases reactivity. As the reactor operates, fuel is depleted but so is the boron. The boron concentration is adjusted so that the boron burns at such a rate that the reactivity excursion, due to fuel burnup, is greatly reduced. One has considerable freedom in setting the fuel and boron loadings, and can, in fact, cause an initial increase in reactivity if enough boron is placed in the fuel element so that the burnup of boron overcompensates for the burnup of fuel. In the case of ETR, the boron concentration for the initial startup core was set at the minimum amount required in order to achieve a 20-day running cycle using the 12 grey rods.

Pressure Vessel

The pressure vessel of ETR was designed to contain a fuel element and control system, experimental components, internal thermal shielding and cooling water at 250 psig and 200 F. The vessel has a diameter of 12 ft at the top and 8 ft in the lower

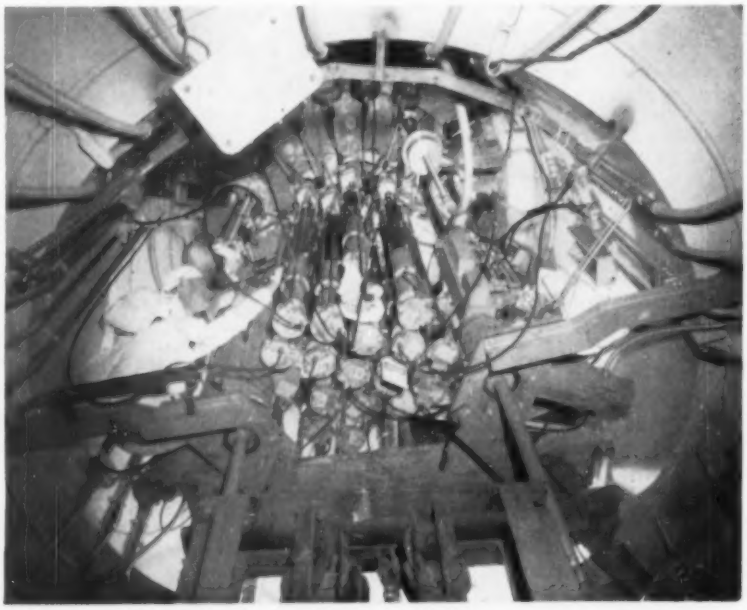


Fig. 4. Complicated control rod drive mechanism at the extreme bottom of the Engineering Test Reactor, looking up from the control rod access room

end. It is made of carbon steel clad on the interior with stainless steel.

The vertical load is carried by a series of support points at the vessel transition midway between the coolant water headers. This support consists of a series of flat plates fastened to the vessel and sliding on flat plates resting on a bed plate and anchored to the concrete. Studs in slotted holes keep the vessel from rotating or moving laterally.

The thermal shielding consists of, a, four concentric cylinders of Type 304 stainless steel around the core and inside vessel, b, the vessel wall, c, an external steel plated and lead filled shield cooled by water in stainless steel tubing. These shields reduce the incident radiation on the concrete biological shield to a relatively low amount and the circulating water in the vessel and the external thermal shield removes most of the heat.

Inlet cooling water flows through a single 36-in. nozzle opening into an internal flow distributor. Outlet is through another 36-in. nozzle. The primary coolant system is based on a reactor inlet temperature of 110 F, 44,000 gpm and 200 psig. The coolant system for the ETR is of the double loop type. Demineralized water in the primary loop passes through the reactor and the tube side of shell-and-tube heat exchangers. This system incorporates emergency cooling capacity, bypass demineralization and degassing equipment. The secondary loop rejects the heat to the atmosphere through a cooling tower.

There are four banks of heat exchangers each in parallel, each bank being stacked in a vertical plane. All parts in contact with primary water are constructed of Type 304 or 304 ELC stainless steel. The space between the double tube sheets is connected to a drain, preventing any leakage from the primary to the secondary sides at the ends of the tubes.

Coolant Shielding

Because of the radioactivity induced in the primary cooling water in its passage through the reactor it was necessary to provide shielding for the coolant piping and the heat exchangers. Between the reactor vessel and the heat exchanger building the primary coolant piping is in a 50-ft tunnel having a minimum of 4-ft of high density concrete shielding in all directions. Several nuclear reactions make the cooling water radioactive. Most important from the point of view of shielding are the ones that form N^{16} and Na^{24}. Both of these isotopes have long enough half lives and sufficiently energetic gamma rays to require shielding.

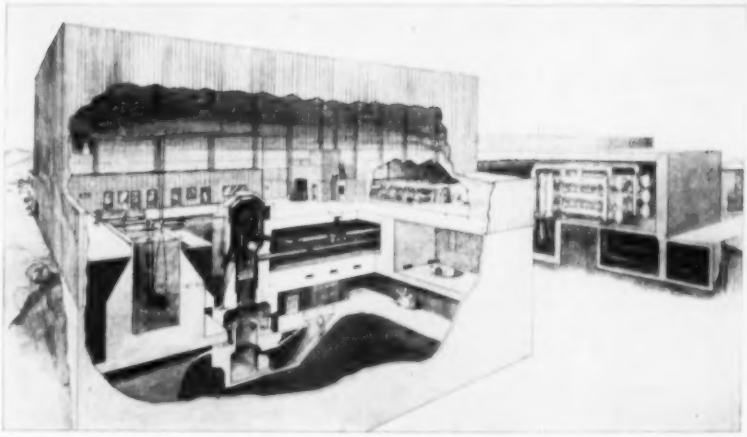


Fig. 5. Cutaway view of ETR. Reactor building consists of 5 floors, 2 below ground. At the left is the T-shaped water canal for storing radioactive material removed from the reactor vessel. Heat exchange wing is shown at the far right

The O^{18} (n,p) N^{16} reaction produces 7 second N^{16}. This is not a long-lived activity. However, since it produces 7-Mev gamma radiation it must be shielded if the delay time between leaving the core and entering an inhabited area is less than approximately 2 minutes. In the case of ETR, the total primary-coolant-cycle time is slightly over 1 minute so the cooling water requires shielding throughout the cycle. The radioactive sodium, Na^{24} has two different origins: (1) Natural Na^{23}, present in the water as an impurity, absorbs a neutron to become Na^{24}. (2) The aluminum atoms in the cladding of the fuel elements will, upon absorption of a fast neutron, eject an alpha particle leaving a sodium atom — Al^{27} (n,α) Na^{24}. If the aluminum atom is near enough to the surface of the metal that is in contact with the cooling water, the recoil energy of the reaction is enough to eject the radioactive sodium atom into the water. The radioactive sodium has a half-life of 15 hours, hence this radioactivity is still present long after the N^{16} activity has disappeared. The high-purity ETR cooling water will have approximately 0.25 ppm of natural sodium as an impurity. Calculations indicate that 10 per cent of this sodium results from this impurity and 90 per cent from the recoil sodium.

Design Considerations

The Engineering Test Reactor is characterized by high specific power, high heat and neutron fluxes, and rigorous mechanical design considerations. This reactor calls for a heat flux of 1,150,000 Btu/ft^2 hr. No reactor so far has approached these conditions under normal operating conditions. This coupled with the need to perform accelerated tests of nuclear fuel and materials in a variety of atmospheres, all within the active portion of this core, make this reactor a very complex device, indeed a test reactor of such high power and com-

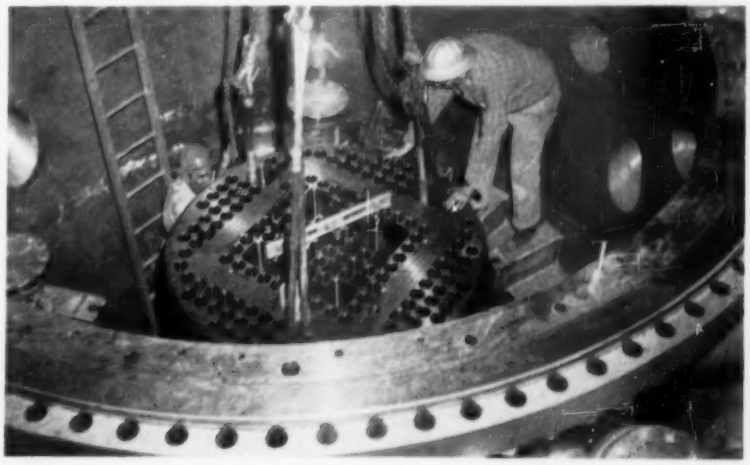


Fig. 6. Workmen lowering ETR grid plate into 35 ft deep pressure vessel. Situated in an inner tank this plate supports the reactor core assemblies and the beryllium and aluminum reflector

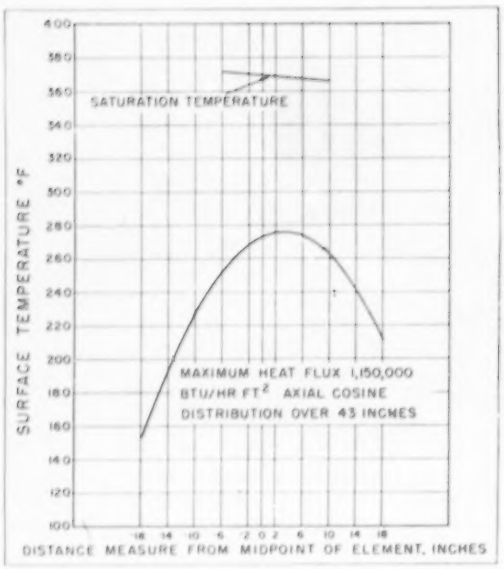

SATURATION TEMPERATURE
MAXIMUM HEAT FLUX 1,150,000
BTU/HR FT² AXIAL COSINE
DISTRIBUTION OVER 43 INCHES
SURFACE TEMPERATURE °F
DISTANCE MEASURE FROM MIDPOINT OF ELEMENT, INCHES

Fig. 7. Specific design conditions of the Engineering Test Reactor. This shows the surface temperature in the hottest element in deg F

plexity has not previously been designed or constructed.

A high power reactor can be a potentially dangerous device and the complications caused by experimental equipment inserted in holes in the active core can make the reactor, potentially, even more dangerous. Every precaution, therefore had to be taken in the design and construction to reduce the possible hazards to a minimum.

A test reactor for materials radiation exists for only one purpose — that of providing irradiation volumes in a high neutron flux to which the materials in question are exposed. The neutron flux level that exists within a reactor is directly proportional to the operating power of the reactor, and inversely proportional to the amount of fuel which exists within the core. The first criterion for a good test reactor is then evident — to build the most powerful reactor within the smallest volume possible and still provide adequate space for inserting the materials which it is desired to investigate. With this concept in mind, it was decided that ETR would be designed for the maximum power that could be produced and still safely remove the heat from the fuel elements to the cooling water. This has resulted in a relatively small core for the power produced, and also a short cycle of operation. The shortness of the operating cycle between refueling periods is, of course, dependent upon the fact that the amount of fuel which is placed in the core to sustain operating life must not be so great that the neutron flux within the reactor is reduced to a level which will prevent rapid testing of the engineering materials under investigation. The cycle which resulted from this requirement is approximately 20 days of operating life between normal refueling periods.

Another feature which was desirable was to make the top of the core as accessible as possible. This feature was needed for ease in refueling and for servicing. The first effort aimed at reducing the complexity of the equipment above the core was that of placing the drives for the control rods below the core, taking access through the bottom head and, therefore eliminating all drives and extension shafts in the upper tank region.

A reactor such as the ETR contains large amounts of fissionable material in the experimental spaces as well as in the core proper. The control of such a core is a matter of careful consideration on the part of the designer to be sure that there is no possibility of having a portion of the reactor operating independently of the balance of the core. This means that for safe design the control rods should be distributed over the core, and particularly when using a grey type of rod, the distribution should be such that an experiment which could be of large reactivity itself may be adequately controlled by one or more of the reactor controls.

Location of the rod drives and the experimental equipment within the ETR posed a problem because of the difficulty of placing all of the equipment for the various penetrations within the small space allotted at the bottom of the reactor. The spacing which resulted is illustrated in Fig. 2 which shows the location of the various control rods with respect to the experimental spaces. The placement of the rods as close together as this was accomplished by removing the drive motor from the in-line portion of the drive and rod and placing it to one side with the use of an extension shaft to drive the rod mechanism up or down.

This, briefly, covers only a few of the many extremely interesting features of this remarkable research tool. Naturally, it involves many other details of design which cannot be described in a single article of this length. As already indicated, no reactor to date has approached the operating requirements set for this reactor and there was little experience on which to make any conservative extrapolation. Of the three ETR variables that could be chosen by the designers, two were taken at their highest practical values. Water velocities of 35 ft per sec and a system pressure of 200 psia appeared reasonable extensions of MTR technology. The third variable, inlet temperature, was selected to provide an adequate margin below saturation temperature. Specific design conditions are shown in Fig. 7. The results are based on an inlet temperature of 110 F, a maximum heat flux of 1,150,000 Btu/ft² hr, a maximum average neutron flux ratio of 2.5, and a heat transfer coefficient of about 9000 Btu/hr/ft² degrees F. The curves in Fig. 7 show that the maximum surface temperature is 90 F below the corresponding saturation temperature.

The ETR project occupies an area of eight acres. The principal facilities consist of five adjoining buildings covering a total of 45,000 sq ft, a separate pump house and a cooling tower. Since ETR is located adjacent to the Materials Testing Reactor (MTR) area which includes complete utility systems and supporting facilities such as laboratories and shops, many ETR utility systems are integrated into the MTR systems. In certain cases the existing MTR facilities were provided with additional capacity.

Construction of the ETR was completed 22 months after the pouring of the first concrete. Delivery of fabricated equipment, especially those items made of stainless steel, was the determining factor in the completion date of August 1957. Close tolerances both in fabricated items as well as installation of equipment, required extreme care but conventional practices could be used throughout. Construction activities were maintained during the winter months by means of special protective measures. Concrete pouring schedules were maintained even when the weather reached the low of 36 degrees below zero, F. The cost came to a grand total of $17,300,000. This figure included $2,700,000 for engineering development and inspection, but the total cost was well under the $18,500,000 originally budgeted for this project.

This splendid record of design and construction was accomplished by extremely active liaison and cooperation between the AEC's Idaho Operation office, Kaiser Engineers as the architect-engineer-constructor, General Electric Co as the nuclear design subcontractor, and Phillips Petroleum Co as plant operator.

Characteristics of High-Temperature Nuclear Power Systems

ATOMIC POWER PLANTS based on the use of a fission reactor differ from conventional fossil-fuel fired plants primarily in the nature of the heat source. In the case of the coal or oil-fired plant, the heat source is a furnace in which the combustion of the fuel takes place. In the nuclear power plant, the heat source is a nuclear reactor in which the fission of uranium or plutonium produces the thermal energy.

The difference in the two heat sources, however, goes far beyond the differences in construction of the two types of equipment. The basic difference lies in the possible temperatures which can be attained in the two systems. In the case of the coal or oil fired furnace the maximum temperatures attainable by the combustion process is on the order of 2000 to say, 2500 degrees F. In the atomic plant, on the other hand, the nuclear reaction is capable of producing temperatures of *millions of degrees*. As a consequence the control of a nuclear reactor is much more critical than the control of a fuel fired furnace where the temperatures and energy concentrations are much lower.

Some idea of the energy concentration in a nuclear reactor can be had from the experiments with Borax I, the experimental boiling water reactor of the Argonne National Laboratory at the Idaho National testing site. In the final test of this reactor a deliberate effort was made to destroy it in order to determine the range of maximum safety in such a reactor. The most violent excursions of the previous year had caused some permanent deformation of the fuel plates of the core, but the plate temperatures did not approach the melting temperature. It was decided that the reactor, which by this time had fulfilled its other purposes, should be sacrificed in an experiment which was violent enough to melt the fuel plates. For this purpose, a control rod worth 4 per cent Keff was completely ejected from the reactor core. To increase the severity of the experiment, it was run with the reactor water at room temperature. Although the ejection of the rod took only about 0.2 sec, the rod was only 80 per cent out of the core when the reactor power reached its peak value. The minimum period reached was 0.0026 sec.

This power excursion melted most of the fuel plates, burst the reactor tank, and ejected most of the contents of the shield tank into the air. The total energy of the burst was 135,000 kw-sec (kilowatt seconds) and the power peak was about 19,000,000 kw!

Curiously enough, despite the fact that such phenomenal temperatures and energy concentrations are possible, nuclear reactor power plants, so far, have operated at temperatures far below those normally used in conventional plant operation. The highest steam temperature of any nuclear power plant up to the present time is the 488 degrees used in the recently completed 5000-kw Argonne Boiling Water Reactor Plant. The reason for these low temperatures, of course, is due to the difficulty of building reactor elements to withstand higher temperatures. It is only within recent months that reactor designs have been proposed capable of operating at temperatures comparable to those attained in the furnaces of our large modern boiler furnaces, that is, in the neighborhood of 2000 F.

New High-Temperature Reactors

One of these is the helium-cooled pebble-bed reactor proposed by S. T. Robinson of Sanderson & Porter and the American Turbine Corp (POWER ENGINEERING, August 1957). This type of reactor would operate with a helium temperature of 1500 F and would be capable of producing steam at 1000 or 1100 F for use in our most modern turbines, or it could be used in conjunction with a closed-cycle gas-turbine system. A nuclear power plant using this type of reactor has been contracted for in Germany and is expected to be ready for operation by 1960. This project involves a 15-mw net (electrical) plant.

Most interesting recent news concerning high-temperature reactor development, however, is in the description of a fused-salt reactor involved in the aircraft reactor experiment at Oak Ridge, Tenn. (now referred to as ARE.) Until May of this year, information concerning the fused salt reactor had been extremely vague. There were rumors that work on this type of reactor was being done at Oak Ridge National Laboratory but no details had been disclosed. A few months ago, however, at the first Inter-American Symposium on the Peaceful Uses of Atomic Energy held at Brookhaven National Laboratory, Dr. Alvin Weinberg, Director of Oak Ridge Laboratory dropped what was virtually a bombshell when he disclosed the fact that in 1954, Oak Ridge had built and operated a fused-salt reactor at 2.5 mw and at 1500 F. This reactor had been part of the aircraft nuclear propulsion program which, of course, had been kept under strict secrecy.

This Aircraft Reactor Experiment involved a molten fluoride uranium-235 reactor operating at extremely high temperature. The circulating fuel was a mixture of molten fluoride salts — NaF and BeF_2, carrying UF_4. Dr. Weinberg compared this reactor with the aqueous homogeneous reactor which is also based upon a liquid uranium fuel principle. He pointed out, however, that the advantage of the aircraft reactor as compared to the aqueous system is its ability to operate at much higher temperature and lower pressures.

Fig. 1. Aircraft Reactor Core which operated at power level of 2.5 mw and at 1500 F at Oak Ridge in 1954. This view shows the thermocouple leads attached to bottom. (Photo Union Carbide Nuclear Co)

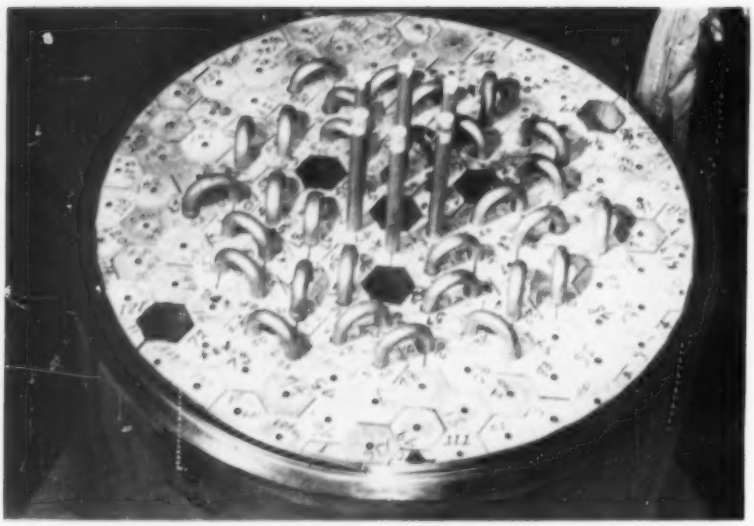


Fig. 2. Top view of fused-salt reactor showing 66 tubes which carry the fuel through the core. Six upright pipes are the fuel inlets. Hexagonal shaped units are the beryllium-oxide moderator reflectors. (Photo, Union Carbide Nuclear Co)

Figure 1 shows a view of the fused-salt reactor, and Fig. 3 is a flow chart of the system in which it operates. A separate beryllium oxide moderator is required because of the low moderating power of the fuel constituents. The fuel flowed in serpentine nickel-alloy tubes through the core where the system became critical. A high-temperature centrifugal pump circulated the liquid to a heat exchanger. As indicated on the flow diagram, a secondary circuit, containing helium circulating at high velocity, was provided to separate the fused salt and the water coolant into which the heat was dumped. The heat generated in the BeO reflector was removed by circulated sodium and also dumped to water by means of an intermediate helium loop.

The reactor stands about 36 in. high and is slightly more than 33 in. in diameter. The large tube at the top is an outlet for the sodium heat exchanger unit, while the smaller extensions represent the two fission chambers (at outer rim) and four regulating control rods.

Performance

Dr. Weinberg said that the reactor first became critical on November 3, 1954, by adding an enriched uranium tetrafluoride concentrate to the barren mixture of molten fluoride salts, and was brought to full power operation on November 9, 1954. The temperature of the fuel entering the reactor was 1200 F and it climbed to about 1500 F before leaving the reactor core. At these temperatures *the reactor glowed red*. The unit ran continuously for about four days and nights and logged more than 90 megawatt hours of high-power, high-temperature operation before it was shut down and dismantled. After operation at full power, it ran considerably longer at full temperature but not full power. Dr. Weinberg did not say why operation at full power was so brief. He did say, however, that the trick was not to make these things critical but to make them run at high power. It was clear that all further work since 1954 on fused salt systems has been for the account of the aircraft program, and further data and information still remains behind the impenetrable curtain of secrecy.

Ultimately this type of reactor might be of considerable importance in the application of nuclear energy to civilian power. Dr. Weinberg indicated that the liquid fuel reactor was extremely stable. It was completely power-demand responsive, and control was accomplished mainly by manipulating the flow of cooling helium to the heat exchanger. Control rods were used mainly to set the operating temperature level.

"Altogether," Weinberg concluded, "the experience with the fused-salt reactor reinforces our view that chemical-type reactor systems merit serious investigation, that even a high-melting-temperature salt mixture can be used as a reactor fuel, and that one way to achieve economic nuclear power — perhaps the simplest way — is to burn U-235 in very high-temperature devices like ARE in which the fuel is liquid . . . The incentive for achieving a successful high temperature reactor that burns U-235 in liquid form is seen from the following considerations. If U-235 costs $17 per gram, and if it can be burned without refabrication (i.e. in liquid form) in a very high-temperature reactor with a thermal efficiency of 35 per cent, the fuel cost, just as a straight burner, amounts to less than 2 mills per kwh. This is competitive with the best conventional fuel costs. The trick is that the system must use fuel in fluid form because, if it were in solid form, reprocessing costs would make the fuel cost much greater than 2 mills." Dr. Weinberg said that high thermal efficiencies comparable with the best modern conventional plants can be attained. The question of whether corrosion in fluoride systems can be held down sufficiently to allow a molten fluoride reactor to operate for many years is one on which Oak Ridge National Laboratory is now working. The fused-salt system resembles the liquid metal fuel reactor (LMFR) in many ways but the fluorides have one great advantage over bismuth: it is impossible to carry enough thorium in solution in bismuth to make a blanket, whereas a fluoride breeder blanket material is available: ThF_4-Li^7F-BeF_2. Fluorides have several disadvantages however; first is their high melting point, 932 F. Furthermore, they are not as good moderators as heavy water and therefore require a greater concentration of U-235. Thirdly, because the fluoride salts used are carriers, they absorb some neutrons and breeding ratios achievable are less favorable than in heavy water systems.

Dr. Weinberg said that if the work being done by a study group at Oak Ridge continues to develop favorably it is planned eventually to build another reactor experiment to demonstrate the long-term reliability of

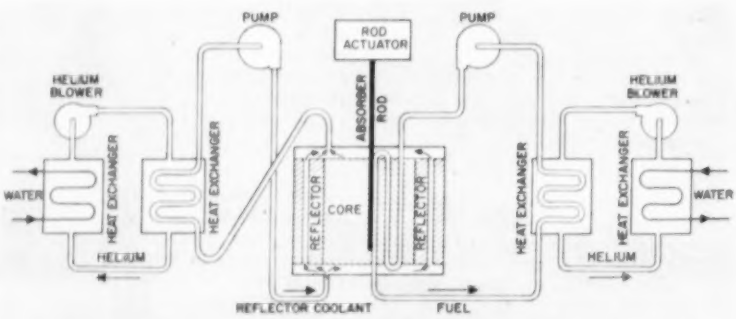


Fig. 3. Flow diagram of the ARE, showing core-cooling and reflector-cooling loops

components and compatibility of materials for application to molten fluoride central station power plants.

High Temperatures and Fusion

While the possibilities of high-temperature reactor systems are intriguing, nowhere in the realm of modern research is the goal of high temperature more exciting than in the study of high-temperature gas plasmas and thermonuclear reactions, because, here, we are talking about temperatures of hundreds of millions of degrees — temperatures which exist only in the stars. The primary objective of these techniques is to bring under control the process of the hydrogen bomb so that it can be peacefully employed for the production of energy. This process — called the thermonuclear reaction — works by fusing together light atoms to form heavier atoms, with the resultant release of energy. This fusion process is not only the basic process of the hydrogen bomb but is also the accepted explanation of the prodigious energy production of the sun and other stars.

Fig. 4. Giant banks of capacitors being assembled at General Electric Research Laboratory to produce large amounts of energy in short bursts for research on fusion reactions

As is well known, now, work in the field of thermonuclear research has been going on in the U. S., Great Britain, and Russia and while only relatively few facts have been disclosed, there seems to be considerable optimism among the research workers as to the ultimate success of the work. Whether this optimism is justified or not there seems to be developing an outline, or at least a shadow, of future scientific discoveries of potentially great significance.

In the United States, most of the work in this field has been done by the Atomic Energy Commission but until recently virtually nothing was disclosed concerning progress. Since the Russian scientist, Kurchatov, speaking at the British Atomic Energy Establishment at Harwell, described experiments with stellar temperatures with controlled fusion as an objective, however, more facts concerning our own work in this field have come to light. All of this work involves high-energy electric discharges in gases.

The problem of bringing stellar temperatures into the laboratory for study is a dream that, until recently, few astrophysicists would have had the courage to express. Yet the work reported already gives considerable substance to this dream. Without doubt, the most important single concept so far is that of magnetic containment. At first sight it would seem impossible to contain a gas at a temperature of many millions of degrees, since all known materials melt and vaporize at very much lower temperatures. An ionized gas, however is a conductor of electricity and as the temperature of an ionized gas is raised it becomes progressively a better electrical conductor. Such a gas, since it consists of electrically charged particles, is also subject to the influence of a magnetic field, and in this fact lies the possibility of developing a magnetic container that will hold a mass of ionized gas — a plasma — so that it never touches the walls of the tube in which the reaction takes place. By passing high-energy currents through a gas, the self-magnetic field surrounding the gaseous conductor tends to constrict the gas into a thin arc by virtue of what is known as the *pinch effect*.

It has been known for a long time that if we want to increase the temperature of an electric arc we should do something to increase the frequency of collisions of the ions and electrons within the *plasma* constituting the arc. This reasoning is supported, in reverse, by the cool temperature of the neon tube. In the neon tube the collision rate is slow because of the low gas density. On the other hand, experiment shows that the temperature of an arc can be raised considerably by producing it in a gas under high pressure in a vessel. It is possible to enclose the arc in a pressure vessel and this, in fact, is the principle of the high-pressure mercury vapor lamp. There the arc is confined in a small quartz tube. Even quartz melts at high temperatures, however, and the pinch effect provides us with a means of achieving high density in the plasma without the encumbrance of an enclosing pressure vessel. It makes use of thermal and magneto-hydrodynamic effects to put the plasma under pressure and so increase its density.

The study of producing high density plasmas is receiving concentrated attention in laboratories throughout the world at the present time. As described in an article in POWER ENGINEERING recently, Dr. W. H. Bostick of Stevens Institute has developed a plasma gun which projects ionized matter at speeds up to 2×10^7 cm per sec. These short-lived clouds of plasma (called plasmoids) exhibit many extremely interesting characteristics and their continued study may throw further light on the production of temperatures high enough to bring about a successful thermonuclear reaction. The production of plasmas has freed us from the top limit of around 10,000 degrees F resulting from chemical reactions, a limit fixed by the energy available in chemical bonds.

Until recently nearly all the work in the controlled thermonuclear field was done under the direction of the AEC in its various laboratories; but since the beginning of the year, at least two industrial organizations have entered this field of research. The General Dynamics Corp, together with the Texas Atomic Energy Research Foundation, have entered upon a four-year $10,000,000 experimental program in the field of fusion. The General Electric Co also has a substantial research program under way. As General Electric points out, this effort cannot be compared in magnitude to AEC's Project Sherwood; nevertheless they do expect to focus the traditional skills of the electrical industry on this primarily electrical problem. G-E's work on fusion has been going on for over a year and is expanding.

Attainment of higher and higher temperature has been the aim of scientists as far back as anyone can remember, but only until the last few years have temperatures much above 5000 or 6000 degrees been attained in the laboratory. Now, however, in the field of fusion research scientists feel that they can approach the ultimate — temperatures comparable to those existing in the stars.

Piping Systems and Metallurgy For Nuclear Applications

Nuclear radiation introduces a new and unique factor in the design of power piping systems and in the selection of material for such systems, particularly where the primary loops are involved. This article discusses the basic mechanism of radiation damage and how it affects piping design and the metals used in piping systems

MANY APPROACHES which have been explored in the development of nuclear power systems have resulted in a wide range of service demands on fabricated pressure piping and the metals used in such systems. The requirements vary in accordance with the different reactor types and on the attendant hazards or consequences of failure of materials or design. While pressures and temperatures used in nuclear power systems so far are not essentially different from those used in conventional fuel-fired plants the nuclear power plant introduces an entirely new factor in operation, and that factor is *radiation*. Radiation is something unique in our environment and the damage it may cause is regarded in many ways, depending upon one's viewpoint. The materials engineer, for example, regards it simply as an additional environment to be considered. The metallurgist views it as another technique for altering the properties of a metal or alloy. To him it belongs in a class with cold working, alloying, and heat treating. The physicist considers it as a portion of the larger field of defect solid state. Again, the chemist sees a technique for altering the course of chemical reactions. To the safety engineer it is merely a potential hazard. Obviously, there is truth in all these viewpoints.

The nuclear design specialist has to take radiation into account in the selection of materials and components. In most cases he has to worry about the detrimental effects of radioactivity but occasionally it is possible for him to make use of possible beneficial effects of radiation. Radiation, for example, may increase the strength of a metal. This is not harmful though the attendant decrease in ductility may be. Generally, however, damage is the principal result because the materials (metal and non-metals alike) are normally in an optimal condition. Thus any change is usually deleterious.

Radiation Damage

Radiation damage originates from the interaction of energetic radiation and matter. This interaction displaces atoms from their equilibrium positions in the lattice structure of the material and places them in non-equilibrium positions. It creates transient, local high-temperature regions; it introduces impurity atoms either through radioactive capture and decay or by inclusion of fission fragments; and it breaks chemical bonds and forms free radicals.

The results of these effects can be listed as follows: vacancies, interstitials, thermal spikes, impurity atoms, and radiation effects. Figure 1 is a chart showing these five principal mechanisms. A neutron entering at the left might give rise to each of them in copper. The grid-line intersections are equilibrium positions for atoms.

While present knowledge does not allow an exact description of just how radiation causes damage it is possible to present a reasonably qualitative picture of the process. Most of the radiation damage in a reactor is caused by high energy particles, fast neutrons and fission fragments. The energy of each of these is tremendous in relation to the energy required to create a *defect*. The uncharged nature of the neutron means that it can interact only by direct collision. Once a collision has taken place, however, the hit atom in turn rapidly creates subsequent displaced atoms. The incident neutron travels many thousands of atomic spacings in the solid before it makes another collision. Consequently the damage resulting from fast neutrons is widely spread throughout a reactor, affecting all components. Fission fragments on the other hand, possessing initially high charge and mass, must dissipate all their energy within a few microns, and their damage, therefore, is usually confined to the fuel volume. The total energy dissipated in radiation is approximately the same for both types of particles, but the spatial distribution is quite different. Other nuclear radiations such as beta particles (electrons) and gamma rays are also capable of creating damage but the amount is usually trivial in comparison with that of fast neutrons and fission fragments.

With regard to vacancies, it is reasonable to assume that the intermingling of atoms in the solid state depends on vacancies and that at a given temperature there is an equilibrium number of vacancies present. A vacancy is an absence of an atom in the lattice pattern of a solid where an atom ought to be. Such voids, however, are not fixed; due to the thermal energy inherent in any solid, vacancies are continually being filled and others created. Hence, there can be diffusion of atoms through a solid. The larger the number of vacancies, the more rapidly diffusion takes place. The creation of vacancies by radiation, therefore, should result in increased damage rates at a given temperature.

It is more difficult to understand the behavior of interstitials. These are atoms not occupying normal positions, or perhaps we should say energy levels, in the atomic lattice. Not enough is known to provide an understanding of the mechanism involved in the production of interstitials but the pronounced increase in yield strength that accompanies even moderate neutron irradiation of metals seems to indicate that interstitials may play an important role in the hardening action.

Impurity atoms are more easily understood. They are atoms of a different element from those constituting the bulk of the solid in question. Usually, the number introduced is small and their effect is small compared to other damage effects. Thus, in materials suitable for reactor applications the problem can usually be neglected. In the fuel volume the production of impurity atoms by fission fragments, however, is a different matter because in this case the impurity effect is much greater.

The most controversial aspect of radiation damage is presented by the thermal spike. This effect results from that portion of the energy that is stored in the form of displaced atoms or trapped electrons, and is dissipated as heat during the collision process. It is generally supposed that this energy creates a momentary region of high temperature that in a good metal may involve an increase in temperature of 1000 degrees for probably less than 10^{-10} sec. While useful in our general thinking about radiation effects, the idea of the thermal spike will require more study before it emerges as a quantitative tool in the interpretation of radiation damage.

Radiation External to Reactor

Fortunately, most of the radiation damage in a nuclear system is confined to the reactor itself, not to the piping systems and components external to the reactor. Very little neutron radiation exists much beyond the reactor, and the radiation which the piping engineer had to contend with is that due to beta particles and gamma rays. Such radiations do affect metals and other materials and they must be taken into account in the selection of components. The design and construction of piping systems and components external to

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* See: Nuclear Power Engineering by Henry C. Schwenk, Henry Pratt Company, and Robert H. Shannon, United Engineers & Constructors, Inc. 344 pages, 131 ill., McGraw-Hill, 1957

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the reactor is more involved with the secondary effects of radiation and with the necessity of keeping highly radioactive fluids confined. The most critical parts of the piping systems are the valves and controlling mechanisms, and much study has been given the specifications under which these devices are procured.

Except in the primary loops handling highly radioactive fluids much of the piping in a nuclear power plant will not differ from that in a conventional steam plant. From a mechanical standpoint, the prime difference in the design of a nuclear plant as compared with that of a conventional steam plant lies in the fuel used and in the methods for coping with resultant radioactivity. Because the primary fluid is in direct contact with the reactor core and is circulated through external circuits special precautions have to be taken in the design of these loops. In the case of a boiling water type of nuclear plant such as the Argonne 5000-kw plant recently placed in operation or in the proposed Dresden Station of the Commonwealth Edison Co, the primary fluid is circulated through the entire turbine cycle. In such plants special precautions have to be taken to reduce the radioactive carryover. At the Argonne plant extensive use was made of stainless steel to reduce the number of corrosion and erosion particles. The piping, valves, and fittings of the auxiliary systems are of stainless steel but because of the high cost of this material, the design provided that only that piping in the feed water and steam systems connected directly to the reactor be of this material.

The thermal insulation of the more highly radioactive parts of these piping systems is of stainless steel wool since normal insulating materials would break down under radiation.

Piping Standards

As far as the piping itself is concerned, the specific considerations of loading, design, fabrication, materials and inspection, are met reasonably well by existing piping standards, as indicated by the following factors which influence design:

Pressure. Pressures in primary and auxiliary circuits may reach several thousand pounds, but are well within the range encountered in conventional power plants, so that the pressure level is not unusual, and considered alone could ordinarily be satisfied by Class II piping or, for lesser service, by classes III and IV.[1]

Temperature. Metal temperatures in primary and auxiliary piping circuits are moderate and, in combination with pressure, are easily met by Classes I, II, and III, apart from the influence of other service demands and material sensitivities.

Heat Transfer. The transfer of thermal energy under the transient

[1] These classes refer to the four classes of pipe listed in the ASA Code for Pressure Piping.

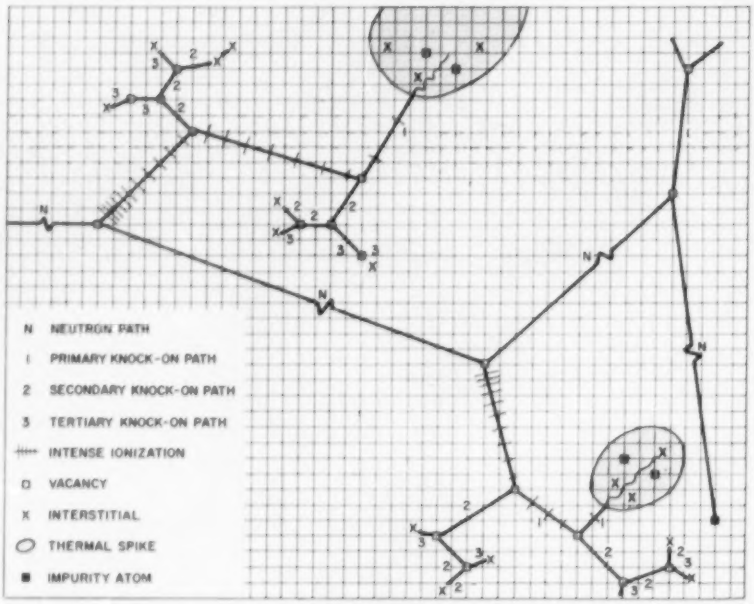


Fig. 1. The five principal mechanisms of radiation damage are ionization, vacancies, interstitials, impurity atoms and thermal spikes. This chart, by D. S. Billington at Oak Ridge, shows how a neutron might give rise to each of them in copper

start-up and power output flow temperature changes or attendant to the re-transfer of the nuclear energy absorbed by the structure to the flowing medium during normal operation introduces thermal stresses whose magnitude is a function of the transient or maintained temperature gradients and the inherent structural restraint to free thermal expansion.

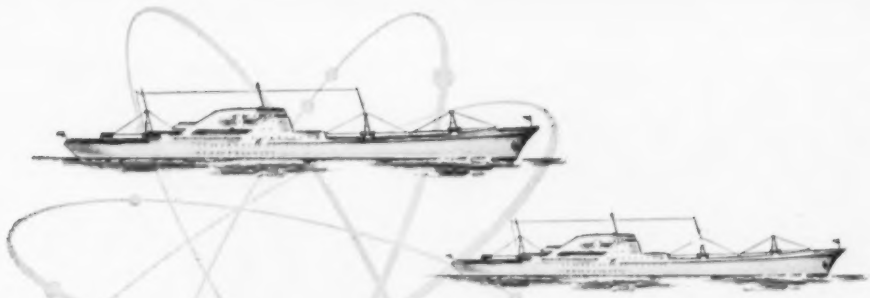
Mechanical loads. Mechanical loading, which includes all static and dynamic pressure, flow and structural demands, would seem to introduce no unusual aspects but is sufficiently varied and challenging in any complex plant to warrant thorough understanding of all potentials. Certain installations may involve shock and vibration either of significant magnitude in itself or capable of flow resonance within proportions of a structure or flow system.

Materials. For critical service the necessity for standards of material quality comparable to the refinement attained in design and fabrication, and the concurrent importance of a sufficient extent of testing and nondestructive examination is emphasized. Material selection must be confined to analyses of established stability and deterioration resistance, and which are not unduly sensitive to fabrication. In view of the limited access for periodic inspection, removable stressed specimens located to reflect critical conditions would be helpful, particularly in following materials performance in initial installations, or for lesser known materials.

From what is known of radiation effects on structure of material at the present time it is likely that radiation will raise the ultimate tensile strength and lower the ductility, somewhat akin to cold work, and lower the impact strength. Such changes, however, will probably not be rapid. If the ductility is not drastically reduced, this alone would not lower the safety factor against static or fatigue rupture, but, in checking effects of radiation, fatigue resistance should be included.

Material sensitivity for fabrication and welding operations, particularly for new materials or when designing for utilization of enhanced properties must be understood. It is important to unquestionably establish that the design properties can be met on the fabricated item considering size, thickness, shape, etc. Even for conventional material, not all problems are conclusively solved, for example, the sensitivity of the austenitic steels to cracking at the edge of welds, particularly in high temperature service, in heavy wall thicknesses or at points of localized stress raisers such as fillet welds. Such steels are also subject to stress corrosion and intergranular attack in the presence of relatively mild corrodents.

Questions relating to the design, erection and inspection at the site, and maintenance of piping systems cannot be considered in a short article but they are largely similar to those which come up in the design of piping systems for conventional high-pressure plants. For nuclear plant service, the use of classification I fabricated piping for radioactive contents is clearly essential, and is so reflected in most installations to date. Non-hazardous content piping within



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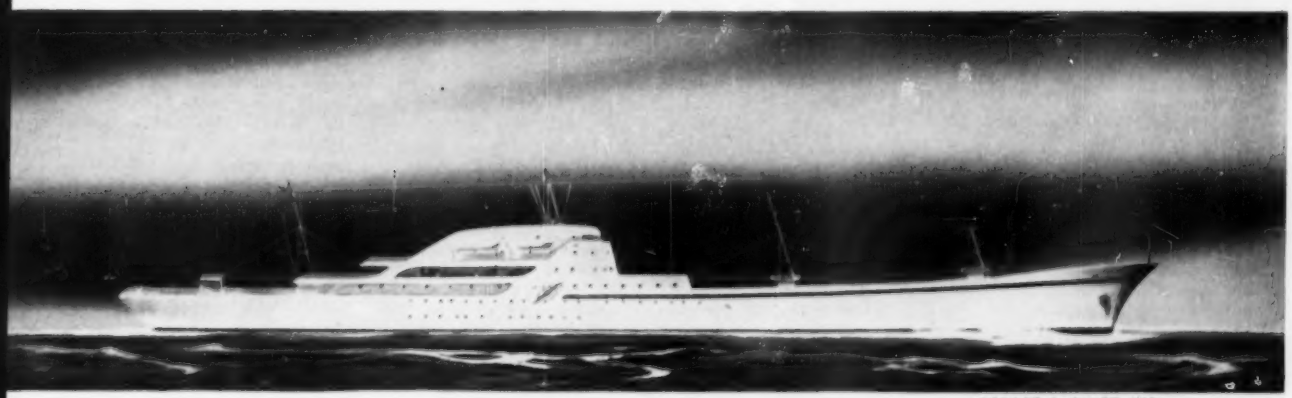

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the radioactive area whose failure might endanger radioactive content lines would justify fully examined construction (Classes I or II), with the higher quality offering more complete assurance as to fatigue capacity and consequent avoidance of expensive repairs or replacement. Fabricated piping external to the radioactive areas is comparable to major power plant service involving combustion where, due to lengthy life expectancy and the necessity for reliable and economic operation, Class I construction is used at least for main steam lines, with the construction class for lesser services selected on individual company evaluation of the hazards and economics involved.

Corrosion in Nuclear Systems

Corrosion presents one of the most important problems in the selection of piping material. For each type of reactor the primary loop piping presents a different corrosion problem. In the case of the water cooled reactors the reactor radiation provides a constant source of dissolved oxygen which, together with the decomposition products, are factors in steel corrosion. Since reactor piping in general must provide for long operation, the accumulation of corrosion products carried from piping to reactor is intolerable and thus the pipe and valves must be of corrosion resistant materials. In the case of liquid sodium heat transfer, there also exists a problem of attack upon the steel and the nickel-chromium austenitic steels are deemed necessary to resist it. Where liquid bismuth is the medium, there are mass transfer considerations and chromium-molybdenum ferritic steels have given the most favorable performance characteristics to date. Perhaps the most extreme piping corrosion is that to be contended with in the aqueous homogeneous systems, where highly resistant lining materials are sought. The organic material reactors using phenolic liquids do not present a special corrosion problem in the piping and apparently steel carbon is a satisfactory material for this system.

The body, bonnet and disc components of primary loop valves must be parts of high quality. The quality requirements for steel valves for nuclear plants were ably covered in a paper by J. J. Kanter, Directing Engineer of Engineering Laboratories of Crane Co which he presented at the Second Nuclear Congress in Philadelphia last March. As he pointed out, the problem of sealing valve stems against leakage is preeminent in the specifications of primary loop valves. Systems for safeguarding against stem leakage to the surrounding atmosphere utilize special provisions beyond ordinary packing glands, such as bellows, canopies, labyrinths of sealing rings, or even frozen seals of the fluid itself (as, for instance, sodium). Where canopies are used it is necessary to contrive remote operating mechanisms such as hydraulic cylinders or magnetic controls. Since bellows operation depends upon the elastic range of the bellows materials, the range of movement, where many cycles of operation are essential at high temperature, must be restricted leading to inordinate size of this component. Since satisfactory packing rings are generally of organic materials, cooling provisions on the packing gland must be provided in the designs where the fluid temperatures are excessive.

Much attention has been given the design and manufacture of valves for nuclear service but no one technique of valve manufacture can universally be advocated for all situations. Where large valves are required steel castings are perhaps the most economical choice and are widely and successfully used. Although forgings have been procured at considerable expense for large valves in certain of the more critical and exacting installations, it seems to be generally agreed among designers that steel castings are satisfactory and in many ways superior.

As pointed out by Mr. Kanter of Crane Company apprehension over the effectiveness of steel valve components seems to stem principally from concern over the possible damaging influence of thermal cycling and thermal shock. The seriousness of such effects, however, is not uniformly pertinent to all types of reactor systems, being functions of the degree and velocity of temperature changes as well as the thermal properties of the fluids contained. The thermal shock in liquid sodium systems for example is greater than with water systems. The materials of construction themselves are pertinent factors where thermal shock is a factor since high thermal expansion and low thermal conductivity can aggravate the transient stresses set up during periods of temperature change. Any kind of stress raiser in a metal section may be suspect as a source of eventual deterioration of a component subject to repeated and frequent thermal cycling as may be the case for a primary piping loop.

Steel vs Forgings

While well made steel castings are quite as acceptable for primary loop applications there seems to be some apprehension regarding their porosity. According to Admiral Rickover many stainless steel castings for valve bodies have been found porous, in fact, he claims that it is very difficult to obtain sound castings consistently. "We have been become reconciled," says Rickover, "to having extra parts made in order to be certain of obtaining sufficient good ones. And we still have not learned why the difficulties arise and how sound parts can be assured." Rickover, however, also cites a number of shortcomings of forgings which have been experienced and his reference to castings should not be taken as an indictment of the potentialities of steel castings for critical service. The use of good inspection methods can serve to determine and locate undesirable discontinuities, voids and inclusions. Once located it becomes a matter of engineering judgement to decide whether a given indication warrants removal and weld repair.

The various details of weld repair, surface treatment of valve parts, heat treatment of parts and the radiographic techniques used for the inspection of parts entering nuclear piping need not be discussed here since these for nuclear piping follow the same general lines as for conventional high pressure, high temperature systems. The problem in meeting the rigid quality requirements of valves and fittings for service in nuclear power plants is a task with which the industry wrestles, with all the means which can be made available.

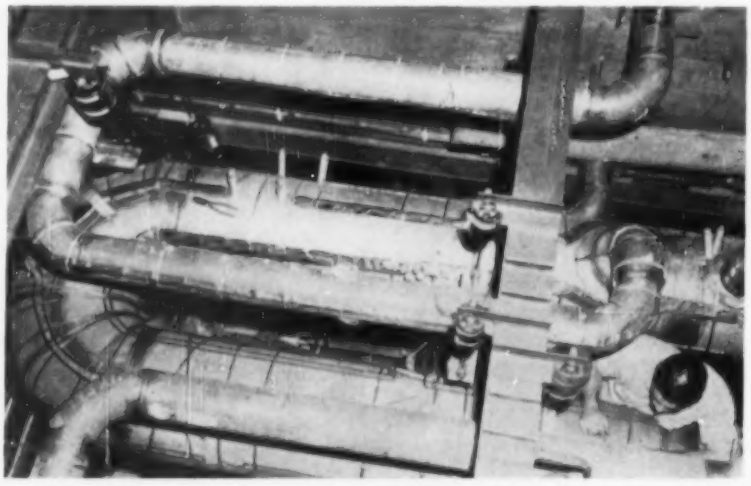

Fig. 2. View of the piping in a sodium-to-sodium heat exchanger built by Atomics International, using Tube-Turns fittings to change the direction of the coolant flow

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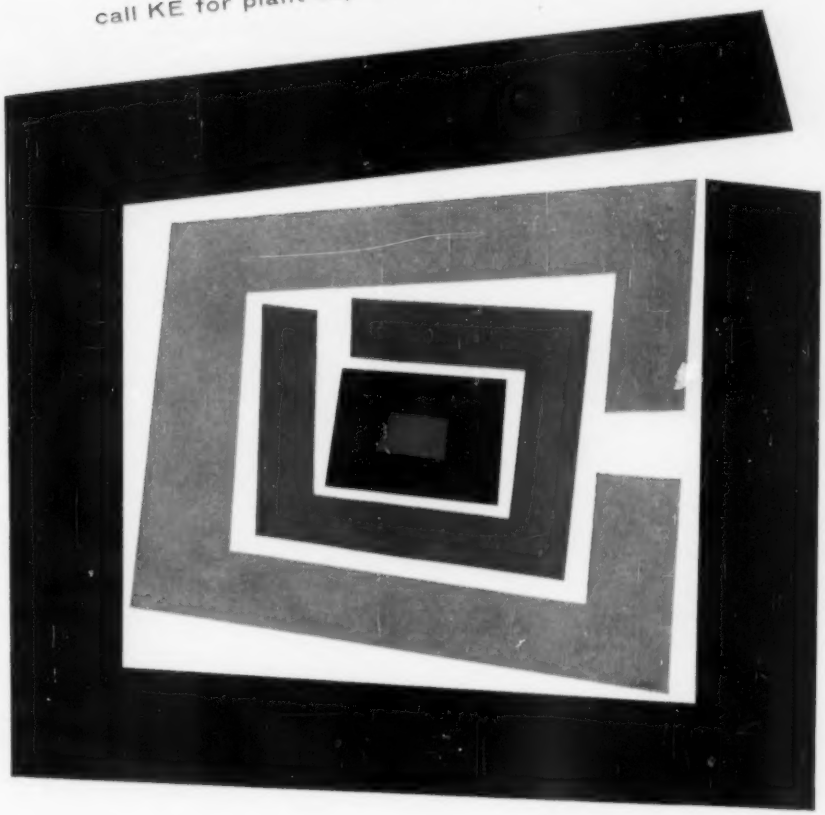

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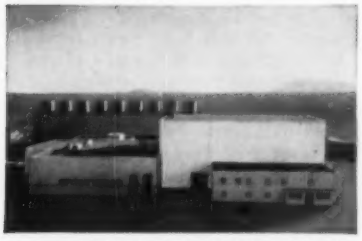

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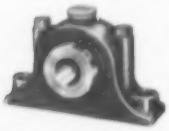

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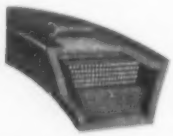

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NEW ENGINEERING BOOKS

Nuclear Power Engineering, by Henry C. Schwenk and Robert H. Shannon. Edited by B. G. A. Skrotzki. First Edition, 344 pages, 5⅜ by 8 in., McGraw-Hill Book Co, 330 West 42nd St, New York, N. Y., 1957. Price $6.50.

For those who need a clear, yet simple and accurate explanation of nuclear power development, this book is probably one of the best published so far. Every important aspect of the field is covered without recourse to mathematics or complex nuclear theory. By using sequence diagrams to explain complex ideas and procedures, it enables engineers and other workers in utility, manufacturing, and consulting firms to readily grasp the main elements of nuclear power production. Particularly valuable is the book's concise description of the power cycle showing how all elements of a nuclear power plant are integrated.

It presents arrangements of various types of reactors — tells how they generate heat and how the heat is extracted. The propagation of fissioning by chain reaction as the basis of nuclear plant operation and how the reaction is controlled is made very clear. In short, this is an excellent book for the beginner in the field of nuclear power.

A word concerning the authors. Henry C. Schwenk is with Henry Pratt Co and Robert H. Shannon is with United Engineers and Constructors. Both have had practical experience in nuclear power development.

* * *

Introduction to Electrical Applied Physics, by N. F. Astbury. First edition, 241 pages, 6 by 9 in., cloth. Philosophical Library, Inc, 15 East 40th St, New York, N. Y., 1957. Price $10.00.

During the last 25 years or so, electrical science has developed in such a way that, effectively, a new subject has grown up, which is perhaps hard to define, but which is neither physics nor engineering in the ordinary way. It is not only a matter of new work, but also of revived interest in and applications of earlier work, which has seemed to be of academic interest only. The author, who is at present Professor of Physics at the University of Khartoum, has felt, therefore, both as a practitioner and as a teacher, that there should perhaps be some change of emphasis in textbooks planned for the senior university student in physics or engineering.

This book is an essay, within a fairly modest compass in this field. In it, an attempt is made to bring together the classical basis of the subject and the elements of some specialized topics which, by the natural processes of technological evolution, are finding their way into all fields of applied science.

Transistors — Theory and Applications, by Abraham Coblenz and Harry L. Owens. First Edition, 313 pages, 6¼ by 9 in., cloth. Published by McGraw-Hill Book Co, 330 West 42nd St, New York, N. Y. Price $6.00.

During the past few years a number of books have appeared dealing with the theory and application of transistors, some good, others only fair. Shockley's own book, published in 1950, probably still remains the classic work on transistors but it is somewhat too difficult for the practical engineer who does not have an extensive background in solid state physics. Shockley together with Bardeen and Brattain, it will be recalled, did the early work in the development of the transistor and only recently were awarded the Nobel prize in physics for their work.

This book by Coblenz and Owens is a much more practical and understandable book for those to whom the transistor is still a new and strange device. It not only gives an extremely clear and concise description of the basic theory involved in transistor action but presents many interesting applications. There is one very excellent chapter dealing with the quantum theory and its application to semiconductor action. Throughout, the treatment of the subject is simple and without recourse to anything more than simple mathematics. Without doubt, this is one of the most informative books on transistors for the average engineer thus far published.

* * *

U.S.A. In New Dimensions — A Twentieth Century Fund Survey, by Thomas R. Carskadon and George Soule. First Edition, 1957. 124 pages, 8½ by 11 in., paper bound. Published by The Macmillan Co, 60 Fifth Ave, New York, N. Y. Price $1.50.

This very excellent analysis of America's needs and resources is really a new phase of a continuing study of this subject by The Twentieth Century Fund. In 1947, the first study, by J. Fredric Dewhurst and associates, covered the full range of economic activity in the United States, and gave a comparison between supply and demand. Again in 1955, a revised appraisal was presented; this, too, was under the capable guidance of Mr. Dewhurst, and carried the title of America's Needs and Resources: A New Survey. From this second survey has come the information for the book reviewed.

Practically every phase of our economy is covered; everything from personal income trends, through health and welfare, to a very sensible prediction regarding the future of America. The book is written in a very interesting style of everyday language.

While U.S.A. In New Dimensions presents a most pleasing outlook in most facets, it does strike a note of caution regarding the accelerated rate at which we are consuming some natural resources. This report is certainly thought-provoking; especially at this time in the early stages of the so-called Atomic Age. We recommend it very highly, as excellent reading for power engineers.

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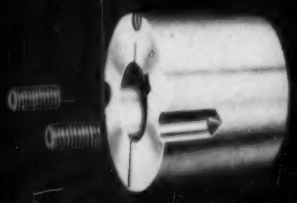

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201 Check Valves — Twenty-pp Catalog 30 presents company's line of tilting-disc check valves made in iron, bronze and steel for working pressures to 3000 psi. Explains operating principles of tilting disc construction, discusses closing without slam, reduced loss of head, other advantages. Includes construction details, sizes. The Chapman Valve Mfg. Co.

202 Water Hammer Control — Cause, effect and control of water hammer in piping systems is the subject of 8-pp Bulletin WH 851. Photos, drawings and curves supplement text, and test data is presented to show efficiency of company's silent check valves in water hammer control. Some typical installations are illustrated. The Williams Gauge Co., Inc..

203 Boiler Blow Off Valves — Bulletin E-125, 24 pp, describes and illustrates the design and construction of company's quick-operating valves, angle valves, Y valves and duplex units specifically designed for boiler blow-off service. Includes dimensions. Everlasting Valve Co.

204 Lubricated Plug Valves — Catalog PV-24, 36-pp, shows in detail a line of iron and steel lubricated plug valves. Many illustrations of the single, screwed and bolted gland type valves are shown, including photos, sectional and detailed drawings. Also included is physical data on dimensions. The Wm. Powell Co.

205 Choosing the Right Valve — Presenting valve selection as a matter of matching the valve's service characteristics with service requirements of the job, this practical 20-pp booklet explains and illustrates basic design features of gate, globe and check valves. It tells, in non-technical language, how each of these valve types works, and where it is suited for use. Disc, stem connection, bonnet and bonnet-joint characteristics are discussed and illustrated. Crane Co.

206 Industrial Valves — Bulletin 507V illustrates and describes company's line of industrial valves for control of air, gas, liquids and solids. Features photos and descriptive detail on a variety of valves, including butterfly valves, wafer butterfly valves, treaded butterfly valves, slide valves, check valves, proportioning valves and others. W. S. Rockwell Co.

207 Butterfly Valve Manual — Forty-pp Catalog B-2 is designed to help power engineers select valve types, understand their characteristics, and determine space requirements. It includes such useful data as: pressure drop and flow tables, conversion tables, theory and application, recommended materials, and describes rubber seat butterfly valves from 4 in. diam up, for handling liquids and gases. Photos, drawings and diagrams amplify the text. The Henry Pratt Co.

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208 Valve Digest — Form 197R is a valve catalog digest furnishing the latest coverage of the OIC bronze, iron, cast steel, forged steel, and lubricated plug valve lines in a condensed form. Valves are classified by type and pressure class, and illustrated; this edition also includes face to face dimensions for each size and type of valve listed. The Ohio Injector Co.

209 Impulse Steam Trap — Bulletin T-1742, 8 pp, describes a line of impulse steam traps designed for a variety of trapping requirements. Contains information on operation, materials and capacities and includes dimensional and specification data, as well as photos of typical installations. Yarnall-Waring Co.

210 Trap Service Guide — To promote better trapping practice, pocket-size 32-pp Bulletin 7511 offers practical tips on installation, testing, and maintenance. Chapters are devoted to inspection and repair, trouble shooting, parts identification. Capacity charts are provided, also tables showing interchangeability of company's trap parts. Other sections deal with strainers, check valves, automatic trap drains. Armstrong Machine Works.

211 Insulated Piping — Bulletin 57-1, 24 pp, on prefabricated insulated piping systems, shows typical uses for Hel-cor pipe units for underground or overhead pipe systems. Also describes Utilidor conduits for protection of underground utility services. Sample specifications are given, along with conduit sizing charts. RicwiL, Inc.

212 Materials For Main Steam Piping — Entitled "The Plastic Ductility of Austenitic Piping Containing Welded Joints At 1200 F," this 16-pp bulletin deals with an investigation into the problem of selection of materials for main steam piping. Gives stress rupture characteristics of type 316 and 347 stainless steel piping adjacent to welded joints. Pittsburgh Piping and Equipment Co.

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213 Multi-Purpose Grease — This bulletin describes Gargoyle Grease BRB No. 1, intended to provide correct lubrication for practically all normally loaded anti-friction and plain bearings. Tells how it resists leakage, affords protection. Socony Mobil Oil Co., Inc.

214 Lithium Soap Greases — This product information bulletin details qualities and specifications of company's multi-purpose soap industrial greases. Advantages of multi-purpose grease use — such as prevention of lubricant misapplication, simplified maintenance procedures are discussed. Sinclair Refining Co.

215 Versatile Industrial Oil — Described in 20-pp Form AD 4078 is an all-purpose oil offering protection for a wide range of industrial equipment, and available in 15 viscosity grades. Discusses six major characteristics of the oil; explains and pictures its use in hydraulic systems, speed reducers, air compressors, electric motors, hydraulic turbines, bearing systems, etc. A chart shows grades available, uses, properties. Standard Oil Co. (Ind.)

216 Bearing Lubrication — Vol. XL, No. 10 of this company's Lubrication

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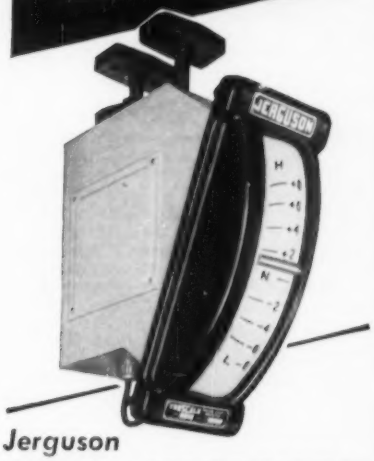

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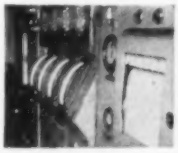

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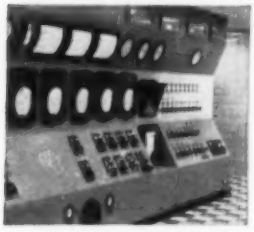

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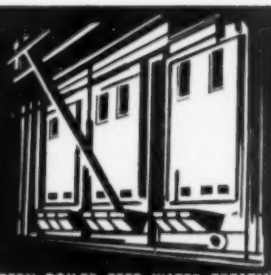

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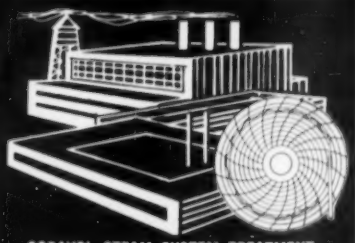

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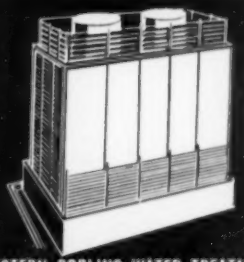

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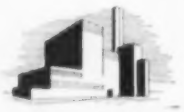

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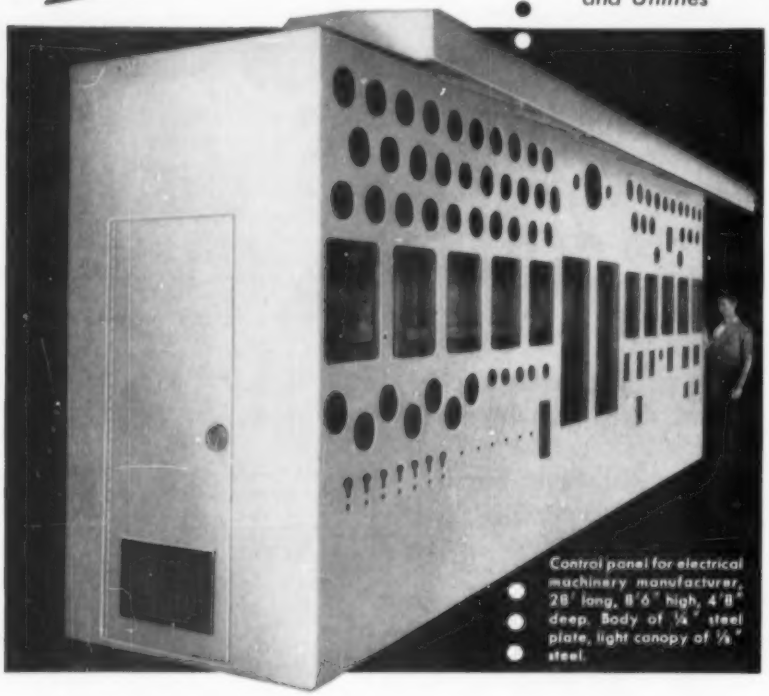

Control panel for electrical machinery manufacturer, 28' long, 8'6" high, 4'8" deep. Body of ¼" steel plate, light canopy of ⅛" steel.

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METAL FABRICATION

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magazine provides an excellent 12-pp article on industrial bearing lubrication. Illustrated with photos and drawings, text covers such subjects as bearing design; bearing surfaces; bearing overhaul; aspects of lubrication, including factors involved, in choice of turbine oils and diesel lubricants, and the deleterious effects of moisture; and the life expectancy of bearing lubricants. The Texas Co.

ELECTRICAL EQUIPMENT

217 Testing Instruments — Bulletin 19-57, 16 pp, features company's electrical testing instruments, including ohmmeters, ground testers, dielectric test sets, motor rotation tester, cable fault locating equipment, transformer turn ratio test sets, corona test equipment, frequency meters, tachometers, others. Includes photos and descriptions of each type, including chief features, operating ranges, and applications. James G. Biddle Co.

218 On Copper Conductors — Publication C-25, 62 pp, is designed to help make the selection of bus conductors easier. Included in booklet are tables regarding such shapes as channels, ventilated square tubes and round tubes. There are tables for other rigid bus conductor shapes, also data on bare copper wire and cable as well as commonly used alloy wires. Also provided is a general discussion of copper, its physical and electrical properties. Photos illustrate many installations. The American Brass Co.

219 Selecting Protective Devices — The Protection Handbook, 24 pp, is based on the 1956 National Electrical Code, and interprets this code into easily read form. It covers the selection of protective devices for electric circuits, motors, appliances and apparatus, and includes a list showing the size to use when ordinary fuse, Fustron dual-element fuse or Fustat is installed. All information is condensed. Fully illustrated, book gives wiring diagrams, motor tables. Bussmann Mfg. Co.

220 Cable Troughs — This 12-pp catalog offers a simple solution to any design problem of change of direction or elevation with a complete set of standard fittings, horizontal elbows, inside and outside vertical elbows, ties, crosses, covers and many special fastening devices to save time and labor. Contains full instructions for installations, load charts, accessory items, some typical installations and full list of distributors. The Globe Co.

TUBING AND ACCESSORIES

222 Rotary Tube Cleaners — Bulletin R-105 presents air and water driven rotary tube cleaners and cleaner accessories. Illustrates several models and heads. Roto Div., Elliott Co.

223 Heat Exchanger Tubing — Cited in this 30-pp catalog are typical cases where cupro-nickel or Monel tubing installed in heat exchangers resulted in substantial savings and better efficiency through longer tube life. Describes applications of this tubing in various instances where unusual water conditions, as to pollution, excessive turbulence, temperature and the like, required such tubing. The International Nickel Co., Inc.

BOILERS, GENERATORS

224 Water Tube Boilers — This 12-pp catalog describes packaged water tube

boilers, in capacities from 8000 to 50,000 lb per hour. Interesting as well as informative, this booklet uses color and illustrations to amplify text. Gives complete data and dimensions for boilers designed for firing oil or gas or both. Superior Combustion Industries, Inc.

225 Shop Assembled Boiler — Sixteen-pp Bulletin G-76 completely describes and illustrates company's Type FM water-tube integral-furnace boiler, made in standard sizes from 2000 to 28,000 lb of steam per hr, pressure to 250 psi. The Babcock & Wilcox Co.

226 Hot Water Boilers — This 20-pp brochure describes and illustrates design, construction, advantages and economies of the C-E La Mont controlled circulation hot water boiler for supplying high pressure, high temperature water for heating systems and process applications. Combustion Engineering, Inc.

227 Steam Generators — Illustrated Bulletin SB43, 20 pp, describes company's VL factory assembled generators combining 2-drum water-type boiler, integral water cooled furnace, brick work, insulation and steel casing. A large cutaway illustration shows design details, and gas travel. Erie City Iron Works.

228 Improved Steam Generator — Bulletin 2000, 28 pp, explains advance design features that distinguish this manufacturer's generator from other unit steam generators. Describes and illustrates engineering differences of component features. Also shows how these components are constructed, assembled and tested. Another section gives data and dimensions for the units. Preferred Utilities Mfg. Corp.

229 Standard Generators — Bulletin B-55-4 describes company's SC economy series of standard steam generators designed to reduce steam costs for industrial plants. Pre-engineered, standardized steam generators offered in nine sizes, with capacities of from 50,000 to 150,000 lb per hour are described, and schematic and cutaway drawings of design features are included. Foster Wheeler Corp.

Do any of these catalogs answer your operating or maintenance needs? Let us know by circling the number of the catalog on the post card provided on pages 123–124. We'll do the rest!

230 Packaged Generators — Bulletin MH 3-54, 14-pp, gives detailed coverage to company's Type MH packaged water tube steam generators which are furnished for oil or gas firing or both, with automatic, semi-automatic, or manual controls. Included are: cutaway illustrations, installation photos, tube arrangement layouts, construction details, auxiliary equipment, dimensions. Union Iron Works.

REFRACTORIES, INSULATIONS

231 Refractory Concrete — Basic information on recommended practice for mixing and placing refractory concrete, used in the metal, power, ceramic, and petroleum refining industry as a material to withstand service temp to 2500 F or more, is presented in this 16-pp manual. Sections are devoted to special properties of refractory concrete, aggregates, refrac-

Improved Operation

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Tru-Lay Push-Pull Controls provide POSITIVE REMOTE-ACTION over long or short distances . . . with fixed or movable anchorages . . . for light loads or loads up to 1,000 lbs., and these units are frequently and successfully used in conjunction with Electric, Hydraulic and Air Controls.

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Advantages of Tru-Lay Push-Pull flexibility and simplicity are pictured below

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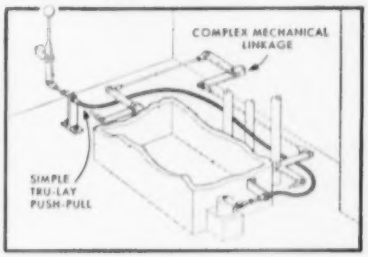
Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Positive Remote-Action and Flexibility, together with Precision and Long Life, explain why TRU-LAY PUSH-PULLS serve designers and users equally well in improving machine operations, whether the application is on such severe service jobs as Bulldozers, Power Shovels and Steel Mill Machinery, or on such light duty work as Photographic Equipment, X-Ray or Business Machines.

Immunity to Vibration makes these TRU-LAY PUSH-PULLS ideal as Remote Controls on shakers and other vibratory products.

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Lubrication of the inner member and conduit are for life.

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Twin Strainer with special back-flushing feature

While flow goes through this compartment
This one is closed for cleaning. Back-flushing water enters at side, drains at bottom.

Elliott Twin Strainers are built in two types. With Type A, one strainer basket is removed and dumped, while liquid flows through the other basket. Type A strainers are also built with a back-flushing feature, whereby the closed-off compartment is cleaned by reversing the liquid flow. Flushing and draining connections permit liquid to enter side of compartment, flow through basket and drain at bottom. Type V, with large-size baskets, is designed primarily for handling oil and viscous liquids.

For over 50 years, Elliott Strainers have been effectively removing objectionable solids from water and other liquids. The resulting trouble-free service has led to installations in power and industrial plants all over the country. Elliott also makes Single Strainers, one type having an Automatic Self-Cleaning feature, the other type with a removable basket for manual cleaning. For details call your Elliott District Office or write Elliott Company, Accessories Department, Jeannette, Pa.

AT-1

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tory insulating concrete, and structural design. Universal Atlas Cement Co.

232 Refractory Castable — Bulletin R-40 describes use of Kaocrete-32, a high temperature refractory castable, in boiler ashpits. A discussion of various methods of ash removal, along with maintenance problems peculiar to each, is presented. Four typical installations are detailed. Refractories Div., The Babcock & Wilcox Co.

233 Insulations, Refractories — This 20-pp catalog features thermal insulations and refractories for general industrial applications. Organized for quick reference, catalog provides information on composition, physical and thermal properties and sizes of the various products. Lists chief advantages, covers materials for efficient control of temperatures from −400 F to 3000 F. Johns-Manville.

WATER CONDITIONING

235 Feedwater Treatment — Process Bulletin B1, "Treatment of Boiler Feedwater by Direct, or Internal Method," discusses advantages of direct treatment, as a complete treating program or as a supplement to external systems. Explains why direct treatment is convenient, economical. National Aluminate Corp.

236 Feedwater Heaters — Open-Coil, tray-type feedwater heaters and purifiers of both deaerating and non-deaerating type are presented in 12-pp Bulletin 117-A. Construction and operational features of the heaters are explained and illustrated, and more than a dozen available models are pictured along with application suggestions. They cover capacities from 3000 to 300,000 lb per hour. Stickle Steam Specialties Co.

237 Water Treatment — Bulletin 5000, 24 pp, explains the reasons for boiler water treatment and tells services offered by company in providing formulations for individual plant requirements. Covers pretreatment, internal treatment, treatment application, blow-down adjustment, test control. Dearborn Chemical Co.

238 Feed Water Deoxygenation — The advantages of chemical deoxygenation of boiler feed water with an aqueous solution of hydrazine are described in 12-pp Bulletin BW 5. How hydrazine serves to maintain boiler in cleanest possible condition, reducing iron oxide scale to a magnetic oxide, is fully detailed, and such considerations as economy and operation, handling precautions, storage are covered. Fairmount Chemical Co., Inc.

239 Valveless Filter — Operation of company's automatic valveless filter is described in this 8-pp illustrated bulletin. Applications and typical operating conditions are detailed and diagrams and photos are included. The Permutit Co.

240 Data on Deaeration — This series of bulletins presents company's line of deaerating equipment for removal of dissolved gases from boiler feedwater etc. Publication 4651 describes Jet-Tray deaerators; No. 4652 covers tray-type units. No. 4653 deals with cold water deaerators used primarily to reduce or eliminate corrosion of piping systems, heat exchangers. No. 4654 describes a surface-type deaerating hot water heater for commercial and institutional use. No. 4653 covers self-contained Uni-Pac deaerators for small and medium size power plants. No. 4635, 12 pp, on atomizing deaerators, details deaer-

ation by atomization and its applications. Cochrane Corp.

241 Corrosion Treatment — "Corrosion Protection of Steam and Condensate Return Systems" is a folder on amine treatment for boiler and condensate systems. This treatment is described as affording surface protection of the metal as well as raising the pH value of the condensate. The Bird-Archer Co.

242 Mixed-Bed De-Ionizers — Practical equipment for mixed-bed de-ionization at flow rates of 5 gph to 5000 gpm is described in this 8-pp bulletin. Advantages of construction and design are detailed, as well as mechanical features, installation operation. Illinois Water Treatment Co.

243 On Demineralization — Technical Reprint T-140, 23-pp, a profusely illustrated article on demineralization, discusses advantages and disadvantages of this process for today's power plants. Developments, trends and applications of both multi-bed and mixed-bed ion exchange are considered, and several case histories cited. A comprehensive bibliography lists 119 separate items. Tables, flow sheets, descriptive drawings, performance curves, process selection charts included. Graver Water Conditioning Co.

244 Improved Crushers — Bulletin 12-C, 16-pp, describes company's line of crushers for reducing coal, coke, glass cullet, gypsum, lime, metal turning, sugar, sulphur and similar lump materials. Covers Knittel ring type crushers, two-stage double-roll crushers, single-roll crushers, and double-roll crushers. Photos, dimensional drawings and full specifications are included. Stephens-Adamson Mfg. Co.

245 Shredders, Crushers — Bulletin 257 describes and illustrates hammermills and shredders, rolling ring and special crushers for reducing chemicals, minerals, ceramics, and other materials including wood waste. Discusses construction features of the line and includes dimensions. American Pulverizer Co.

INSTRUMENTS, CONTROLS

246 Boiler Feed Control — Bulletin 1003, a 12-pp catalog on boiler feed regulators, is illustrated with large application photos and detailed schematic drawings and charts. Relay and direct operation are covered. Case studies of representative boiler loads are presented to show stability of the Flowmatics in controlling feedwater. Copes-Vulcan Div., Blaw-Knox Co.

247 Meters and Controls — Over 100 measuring, transmitting, receiving, recording and indicating instruments and control components, including those introduced within the last year are described in the 8-pp 1957 edition of company's Bulletin G15-1. Applications, ranges, and detailed literature references are given for each product. Bailey Meter Co.

248 Resistance Temperature Detectors — In 8-pp Publication 30161D are described a line of remote temperature-sensitive elements for use in indicating, recording, controlling and monitoring equipment. Operation, application and construction details of the resistance temperature detectors are presented, along with specifications and ordering tips. Instrument Div., Thomas A. Edison, Inc.

249 For Feedwater Analysis — Bulletin 148BP contains a technical discussion

ENGINEERING . . .
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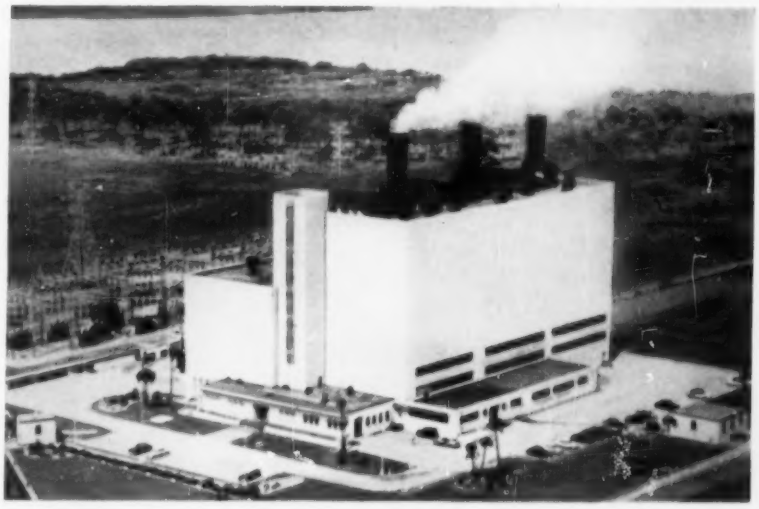

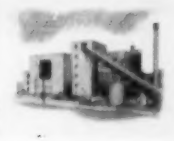

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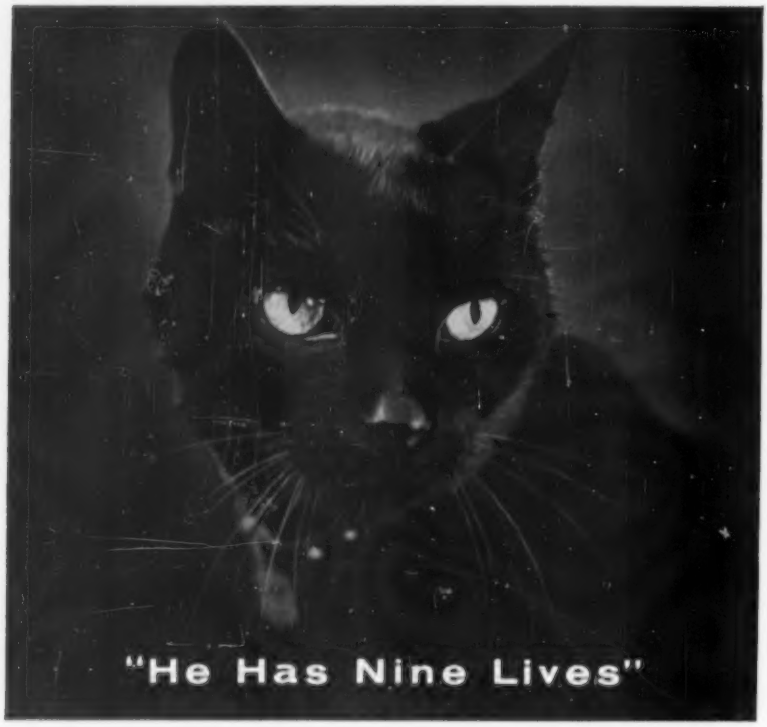

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of manufacturer's analyzers for determination of dissolved oxygen and hydrogen in feedwater. Discusses both O and H units as to function, ranges, accuracy. Cambridge Instrument Co, Inc.

250 Instruments, Controls — Condensed Catalog 1537 offers brief application information on manufacturer's line of instruments. Fully illustrated, covers draft and pressure instruments, flow meters, liquid levels and pressure gages, CO_2 meters, pneumatic transmitters, positioning operators, temperature instruments, boiler feedwater controls, others. Includes references to detailed literature on each type of equipment. Republic Flow Meters Co.

251 Guide to Gages — Catalog 300-B, 112 pp, features Ashcroft Duragauges, Maxisafe, pneumatic receiver, recording, quality, drawn casem chemical and special application gages. Also presented are gauge testers, pneumatic transmitters, gages for nuclear energy. Engineering data and charts are provided. Instruments shown cover dial sizes from 2 through 24 in., pressures from 30 in. vacuum or a few ounces up to 100,000 psi. Manning, Maxwell & Moore, Inc.

252 Easy Reading Gage — An all-hydrostatic remote reading gage for boiler water and other liquid levels is described in Catalog 500, Section CO. Pictures improved visibility, other advantages offered by this gage, and explains operation. The Reliance Gauge Column Co.

253 Remote Reading Gages — Eight-pp Catalog 291, revised, shows new designs in remote reading liquid level gages, including the Red Flasher Truscale. This has a scale which flashes continuously in red for a positive warning when boiler water level gets too high or too low. Profusely illustrated with photos and engineering drawings, catalog covers gages in four pressure groups from under 900 to over 1500 psi. Jerguson Gage & Valve Co.

254 Pressure Regulators — Form 1011, on flow regulators, provides selection data with photos on three principal types of main valves and pilots. Also illustrated by line drawings are three suggested applications of regulators. A steam capacity table for the selection of main valve size is also shown. Spence Engineering Co., Inc.

255 Cooling Controls — Bulletin 710B describes company's self-powered cooling controls for compressors, stills, solvent coolers, degreasers, oil coolers, small engines, condensers, others. Includes operational drawing and hook-up sketches. Sarco Co., Inc.

256 Ideas on Push Pull Controls — Included in this "Idea File" are answers to a power engineer's questions on the use of push-pull controls. A general information booklet discusses remote control applications, explains construction and operation of company's Tru-Lay controls. Separate bulletins are devoted to standard assemblies, bracket-type head controls, micro controls and hand-operated controls. Automotive and Aircraft Div., American Chain & Cable Co., Inc.

CORROSION CONTROL

258 Corrosion Control — Treatment of industrial equipment to control corrosion cannot be a hit-and-miss proposition cautions this 6-pp folder. Examples are given of optimum control measures that may avoid costly, unsound treatment

procedures, including minor physical or operating changes. Hall Laboratories, Inc.

259 Corrosion, Abrasion Control — Modern practices and products for the positive protection of metal equipment from the effects of corrosion and abrasion are described in this 16-pp bulletin. Covers factory and field application of rubber or synthetic linings to metal parts or products, and maintenance coatings available for application by plant personnel. Goodall Rubber Co.

260 Guide to Corrosion Prevention — How Bitumastic protective coatings aid in fight against corrosion is told in this 12-pp booklet. Discusses corrosion as a universal industrial problem, role of protective coatings in cutting costs and lengthening service life of structures and equipment, and gives data on several coal tar-based coatings intended to solve a variety of corrosion problems. Twelve typical case histories covering use of these protective coatings in varied industries are described. Koppers Co., Inc.

MECHANICAL POWER TRANSMISSION

261 V-S Drive Selection Tips — Bulletin 20P50, 44 pp, carries handy multicolor tables for quick and easy selection of variable speed Texrope drives. In addition to providing these tables for A, B, C and D section variable speed drives, booklet includes information on design features, drive principles, horsepower rating tables, speed range table. Allis-Chalmers Mfg. Co.

262 Internally Geared Power — Featuring latest design improvements in gearmotors and embodying 60 multicolor illustrations, 16-pp Form F-1880 shows comparative advantages of gearmotors, lists ratings from ½ to 30 hp with gear ratios as high as 10:1. Cross-sectional details and enlargements of outstanding features are included, as well as a discussion of use of elliptoidal helical gears, and a chart graphing degrees of tempering of gear teeth. U. S. Electrical Motors Inc.

263 Fluid Drives — Bulletins 9419 and 9519 are an illustrated catalog and selection guide on company's new Type VS Class 2 Gyrol fluid drives. Catalog discusses advantages and applications of the drives, covering speed control, power savings, simplified installation, etc. A sectional view shows construction and principle of operation. Dimensions for six sizes of drives are provided. Selection guide consists of tables indicating proper drive to use. American Blower Corp.

264 Spherical Roller Bearing — Eight-pp Bulletin A668 describes design and operation advantages of company's Spher-Align pillow block with improved spherical roller bearing. Complete selection data and specifications are tabulated. Dodge Mfg. Corp.

PACKINGS, SEALS

265 Packings and Gaskets — Catalog P-100C, 32 pp, covers 95 most popular packings and gaskets in company's line, furnishing details of construction, service recommendations and size information. Includes charts showing applications. Packing Div., Raybestos-Manhattan, Inc.

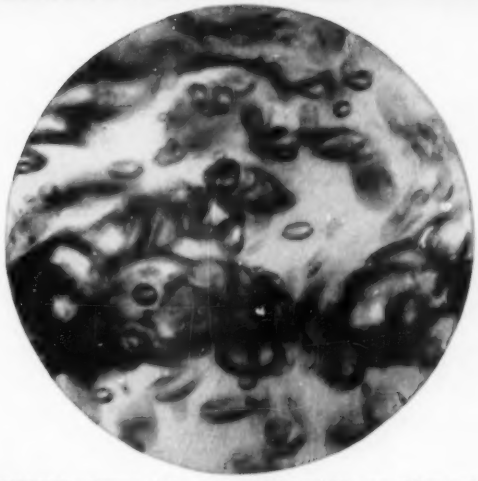
266 Mechanical Packings — Featured in 24-pp Catalog 56 are several recent packing developments including the

BEFORE CONCENTROL—Foaming of highly alkaline solution in glass test cylinder.

HERE'S PROOF:

CONCENTROL

CONTROLS FOAM AND BOILER WATER CARRY-OVER



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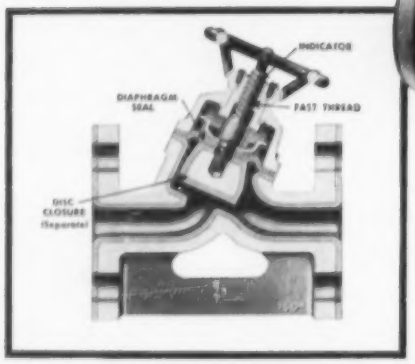

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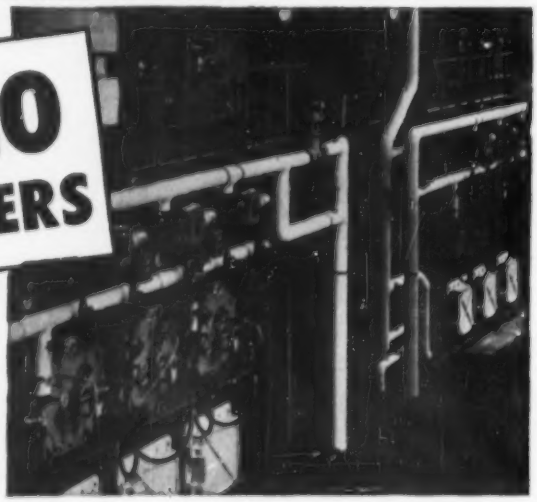

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Designed for operation with either gas, oil or both with natural or forced draft. They can be depended on for maximum combustion efficiency.

ENCO Interchangeable Oil-Burners can be changed instantly to operate by either steam or mechanical pressure atomizing over a wide capacity range.

ENCO Oil Atomizers are applied to various types of standard pulverized-coal and gas-burner units cold starting or for full load operation when coal or gas is not available, or when oil is the more economical fuel.

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267 Mechanical Seals — Bulletin S-205-2, 8-pp, covers the complete line of chemically inert mechanical seals for handling all types acids, corrosives, solvents and gases. Provides construction, service and application information, installations and engineering details. Crane Packing Co.

PUMPS AND PUMPING

268 Controlled Volume Pumps — Bulletin 953, 24 pp, describes and illustrates use of controlled volume pumps in industrial water treating systems. Construction and operation features are described, capacity-pressure ranges and speed and stroke length adjustments are charted. Typical chemical feed and water treating systems are presented through text and diagrams; and an analysis of boiler water treating systems, cooling water treating problems, and systems for waste and sanitary water treatment included. Milton Roy Co.

269 Flow Control — Twelve-pp Catalog 800 describes four basic models of precision proportioning pumps for uses requiring accurate and positive proportioning of flow in range of 0 to 730 gph. Materials of construction, capacities and pressures are shown for each. Diaphragm valves are discussed and their features noted. A section on plastic valves and diaphragms features those for temperatures to 300 F, and includes diaphragm material chart covering selection for use with air, water, corrosives, slurries, liquids, gases. Hills-McCanna Co.

270 Non-Clog Pumps — Bulletin 121MV features Mono-Vane single passage impeller pumps designed for handling heavy settleable solids, long stringy solids, effluent etc. Both horizontal and vertical types are presented along with specifications. Mono-Vane impeller is described in detail, and various models of the pumps are pictured. Aurora Pump Div., The New York Air Brake Co.

271 Steam Pump Care — Bulletin G-2280 "How to Install and Take Care of Steam Pumps," is a 24-pp booklet containing a step-by-step series of 88 illustrations showing how to increase the service life of all types of steam pumps. It offers 28 tips on proper installation of the pumps, 54 tips on care techniques. Section on installation provides information on suction, packing the pump, starting it, and trouble shooting. Section on maintenance deals with such subjects as steam valves, liquid piston and rod, piston packing, liners. Worthington Corp.

272 For Abusive Pumping Jobs — Catalog 4906, 36 pp, covers centrifugal pumps for wide industrial use and especially adapted to handling ashes, abrasive mixtures, slurries, hot and corrosive liquids. It describes several basic types: a horizontal shaft, single-stage side suction pump; a horizontal shaft, single-stage, rear-entrance automatic priming pump; vertical shaft pumps with standard, overhead and quill bearings for wet pit applications. Nagle Pumps, Inc.

FUEL BURNING EQUIPMENT

273 Oil and Gas Burners — Bulletin OB-53, 28 pp, gives principles of selection and application of oil or gas burners, or a combination of both for standard and wide capacity range operation, together with air registers and fuel oil heating and pumping sets. Conversion table shows approximate relationships between quantity of oil burned, boiler capacity and air required for combustion. The Engineer Co.

Postage-free cards for ordering catalogs are on page 113. You may also use the cards to order literature mentioned in the ads.

274 For Burning Refuse Fuel — This 8-pp bulletin describes refuse fuel burning equipment, including a pneumatic refuse fuel distributor which spreads refuse fuels such as bark, wood chips, and bagasse uniformly over the grate surface. Discusses construction features of various components. Riley Stoker Corp.

275 Steam Atomizing Oil Burners — Sixteen-pp illustrated Bulletin 21 describes steam atomizing oil burners and auxiliary equipment for use with heavy oil or tar in boilers, stills, dryers and other furnaces where steam or compressed air is available for atomizing the oil. Includes information on furnace design and construction. National Airoil Burner Co., Inc.

OTHER EQUIPMENT

276 Product Guide — Manufacturing facilities for company's line of steam turbines, turbine generators, ship propulsion units, feed pumps, centrifugal compressors, blowers, centrifugal pumps, reduction gear, and other products are described in this profusely illustrated 50-pp catalog. Photos show manufacturing procedure. De Laval Steam Turbine Co.

277 Precipitation Products — Twelve-pp Bulletin G406 contains helpful information on company's various precipitation products, including electrical precipitators, multiclone mechanical dust collectors, combination multiclone-precipitator units, Dualaire filter-type dust collectors and Holo-Flite processors. Also illustrates a number of typical installations. Western Precipitation Corp.

278 Preheating Combustion Air — This well-illustrated 36-pp booklet explains fuel savings and increased performance made possible by using waste heat in flue gases to preheat incoming combustion air. Also covers increased boiler output, ability to use lower grade fuels, other advantages afforded. Booklet contrasts regenerative with recuperative preheaters; explains operating principle and structural details of the Ljungstrom air preheater. Applications for other than power boilers are also covered. Air Preheater Corp.

279 Sheet and Plate Fabrication — Illustrated in 40-pp Bulletin F-3 are products of this manufacturer, and equipment used to produce special sheet steel and alloy parts. Shows control panels, switch gear housings, cubicles and other electrical enclosures, boiler air ducts, smoke breechings, tanks. The Kirk & Blum Mfg. Co.

280 Steel Floor Plate — Skid resistance and other advantages of multigrip

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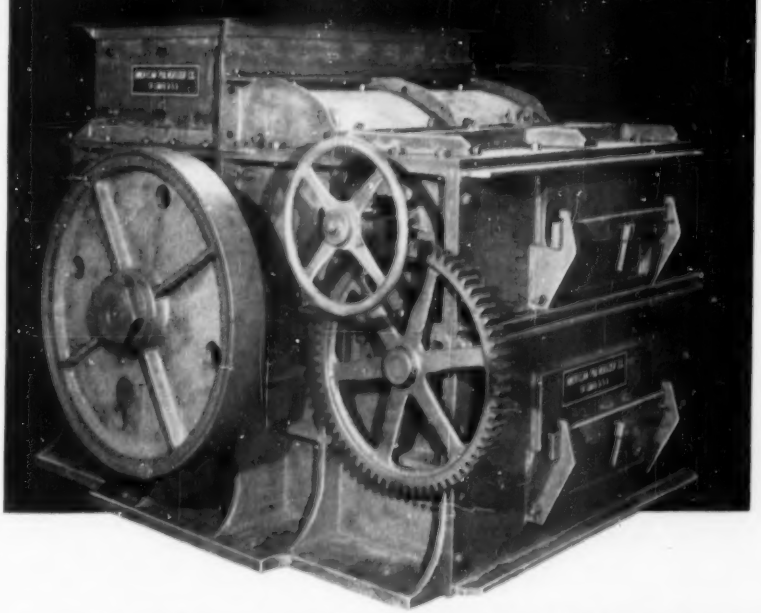

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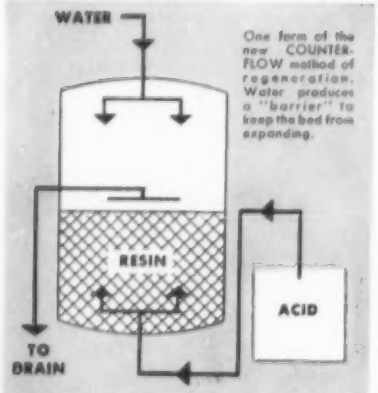
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rolled steel floor plate are stressed in this illustrated bulletin. Also gives dimensions, weights, and information on allowable loads. United States Steel Corp.

281 Metal Laminates — Types of metal laminates, metals which can be laminated, and use in heat exchangers, electronics and other applications are detailed in this illustrated 8-pp bulletin. Advantages and properties are described, and size data given. Bridgeport Brass Co.

282 Product Guide — This illustrated 8-pp bulletin contains descriptive information on company's industrial products division and the products it manufactures, including power plant equipment, bridges, pressure vessels, process industry equipment and a wide variety of specialized products. Describes manufacturing facilities and includes production photos of manufacturing processes. Industrial Products Div., Maryland Shipbuilding & Drydock Co.

283 Engineering For Atomic Power — How $400 million in coin silver weighing 14,000 tons were borrowed from the U. S. Treasurer for use as electrical conductors at the atomic energy plant in Oak Ridge, during the war when copper was scarce, is told in this 36-pp illustrated booklet. Describes the firm's role in the development of atomic energy and outlines its activities in peacetime applications. Stone & Webster Engineering Corp.

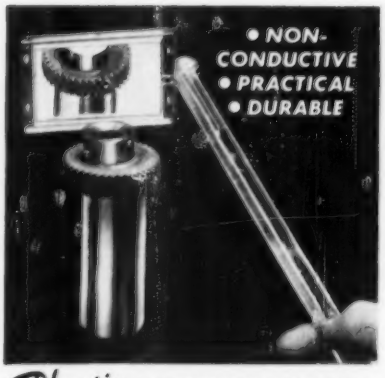
284 Refrigeration Condensers — Engineering data on a complete range of sizes and types of refrigeration condensers are featured in 38-pp Bulletin RC-2. Ratings in tons refrigeration are tabulated for large and small ammonia condensers, vertical ammonia condensers, ammonia condenser-towers, freon condensers and freon condenser-towers. Selection data, dimensions, dimensional diagrams and tables of pipe sizes given. Henry Vogt Machine Co.

286 Steam Turbines — The advantages of company's solid wheel turbines, axial flow turbines, single stage and multi-stage, are outlined in illustrated Bulletin S-140. Describes various models in their line and includes application photos. The Terry Steam Turbine Co.

287 On Coal Burning Plants — Presented in this illustrated 20-pp booklet, "More and more firms are burning coal the modern way . . ." are eight case histories of notable coal burning plants. They include industrial, commercial and institution power plants, both modernization and new construction. Economy and other advantages of coal as a fuel are stressed. Bituminous Coal Institute.

288 Turbine Speed Control — Thirty-pp wire-bound Bulletin H-21 is titled "Fundamentals of Turbine Speed Control." It is an elaborately illustrated, educational booklet intended to clarify operation of common types of automatic speed control for steam turbines. An introductory section covers general fundamentals of automatic control systems, and includes a key to control terminology. Simplified diagrams show operating principles of actual control systems. Elliott Co.

289 Overhead Heating Units — Bulletin P 1-57, 16-pp, contains photographic reproductions of overhead gas-fired heaters, as installed in a variety of commercial and industrial plants. How this type of heating was used to solve specific heating problems is detailed. Prat-Daniel Corp.



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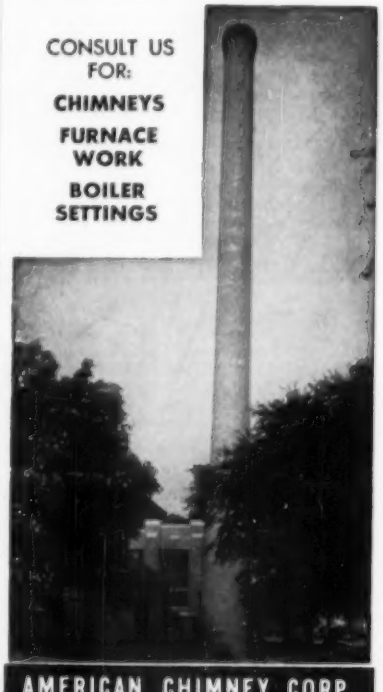

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continued from page 58

34—TERMINATORS, FITTINGS for interlocked armor cable

Terminators, supports and splicing fittings are announced for all types of interlocked armor cable. Eleven terminators in the line include watertight and non-watertight types and upright, horizontal and inverted types. Nominal diameters over armor range from 0.45 to 4.28 in. Typical functions are to terminate and ground cable armor and secure and seal cable entrance into a cabinet or terminal box. Two models support vertical cable where it enters the bottom of junction or pull boxes. There are also terminator adapters for use with interlocked armor cable having a sheath under armor, angle adapters, and mounting brackets.

Sixteen types of fittings include materials required to make the cable splices, such as two-way straight splices or three- or four-way Y and X splices. Types for both varnished cambric and rubber insulated interlocked armor cable are offered. These fittings are designed for maximum voltages from 1000 v to 15,000 v grounded and/or ungrounded neutral and to 5000 v shielded or unshielded. Bulletin 135A gives engineering data. O. Z. Electrical Mfg. Co.

Described on these pages are new and improved products. Use Reader Service Cards on pages 123–124 to ask for more information on them. Just circle the item numbers of all the products in which you are interested.

35—PURGE SEQUENCE VALVE for industrial boilers

Fig. 1000 is a purge sequence valve designed to provide a secure and hazard-free means of steam purging or scouring oil burner tips in industrial installations. The device is a triple interlocked valve system actuated by a single handwheel. It dictates an inflexible and irreversible sequence in the control of atomizing steam, fuel oil, and steam for purging burner tips. The cycle prevents admission of oil to a hot firebox before the admission of atomizing steam, company says, eliminating possible human error and boiler explosion in manipulation of three separate valves usually required in this type of installation. Atlas Valve Co.

36—LIQUID SAMPLE COOLER works with high pressures

Designed for use with pressures up to 5000 psig and temperatures to 1200 F, this small, low cost liquid sample cooler is a shell and tubular coil type heat exchanger applicable to feedwater heaters, hot water softeners, and high and low pressure boilers. The unit is also suggested for cooling samples in chemical, refinery and paper processes. All parts of the cooler, which is housed in a stainless steel shell $3\frac{1}{2}$ in. in diameter by $11\frac{1}{4}$ in. long, are welded. The cooler has Type 316 welded stainless tubing for pressures to 3500 psig and temperatures to 700 F, and stainless No. 20Cb tubing for the higher pressures and temperatures. The cooler features the counter-flow principle to enable the cooling of liquid samples to temperatures approaching those of the inlet cooling media. Flow passages are designed to promote high rates of heat transfer and to eliminate short circuiting or pocketing of both sample and coolant. Technical Engineered Products, Inc.

37—VOLTAGE CONVERTER changes single to three phase

Weighing only 39 lb, this compact, lightweight converter changes single phase, 115-v, 60-cycle a-c to three phase, 230-v, 60-cycle current, it is announced, holding frequency constant within a fraction of a cycle. The aluminum alloy frame houses capacitator starter as well as both output and input receptacles, and is about 10 in. high without carrying handle. Intake and exhaust air vents are located in lower halves of endbells, making the converter drip-proof, it is said, and heavy duty grease sealed ball bearings serve to reduce noise. Kato Engineering Co.

38—MACHINE MOUNTING reduces noise, vibration

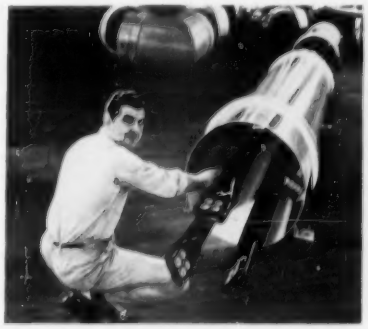
Effective and economical noise reduction and vibration isolation of industrial machinery and air conditioning equipment are claimed for Shear-Flex Mounting Pads. Shear-Flex is an 18-in. square by $\frac{3}{8}$-in. thick oil-resistant Neoprene sheet with a cross-ribbed structure designed to offer deflection throughout the load range of 5 to 70 psi. Alternately raised ribs provide skid-resistant surfaces. Light loads ride on the high ribs, and heavy loads are supported by the entire ribbed surface. Recommended loading is 50 psi, the maximum load impact. For maximum efficiency, Shear-Flex can be used in multiple layers with ribs crossing at right angles. Installation is simple. Shear-Flex is cut to size with scissors or knife and placed under equipment legs or bearing plate. Bolting or cementing aren't required. Engineering book and sample swatch are offered. Vibration Mountings, Inc.

39—POWER CONDUCTORS of bolted aluminum construction

These aluminum power connectors are designed for maximum strength, conductivity, and long life. Company says the heavy-series bolt design provides high contact pressure with low connector stress. It is pointed out that the nested bolt heads cannot turn, permitting easy, one wrench installation. Royal Electric Mfg. Co., Inc.

40—NON-SEGREGATED-PHASE BUS is sealed and insulated

This 4.16-, 7.2- and 13.8-kv 1200–3000 amp non-segregated phase bus is sealed with cork Neoprene-gasketed split half round covers and insulated by air and porcelain insulators. No organic materials are used for insulation, according to manufacturer. It is claimed ideally suited for generator leads to transformers, for connecting transformers to switchgear assemblies, for inter-connecting switchgear assemblies, and for distribution of light and power in industrial and office buildings. Other features announced include flexible or laminated connectors to make sections easier to install. The circular design requires less space for installation and is suggested for indoor or outdoor use. I-T-E Circuit Breaker Co.



41—POTENTIAL TRANSFORMERS of butyl-molded construction

Designed for circuits up to 5 kv, both indoor and outdoor types are available in this butyl-molded potential transformer line. Specifications include 0.3 ASA accuracy and a 60-kv impulse level. Ratios of 20:1, 35:1, and 40:1 are pro-

vided for line-to-line or line-to-neutral use on 4800-v systems and lower. Thermal capacity is increased, it is noted, with transformers able to carry over 600 v-amp at 30 C ambient without overheating. The outdoor type has stainless steel accessories. It also has greater creepage distance to reduce possibility of flashovers. Both types are reported easier to install, look better, and provide greater service reliability. Butyl-molded construction serves as a combined bushing, case and insulation. These transformers are announced as fire and explosion-resistant and as having a low-stable insulation power factor due low moisture absorption of butyl. Company says that no ionization is encountered at operating voltage, so that radio interference noise is eliminated. General Electric Co.

42—ADJUSTABLE MIRRORS make maintenance easier

These inspection mirrors are similar in appearance to dental mirrors. They have long plastic handles, adjustable by the touch of a thumb to any angle within a 45-deg. arc. With them, you can see behind gears, into a tank, inside the angle of a pipe or casting, underneath a fitting, around a corner — have a look at practically any part hidden from direct vision. The mirror itself has a plastic frame and back. Round or rectangular style mirrors are furnished in several sizes, and a magnifying mirror is also available. The mirrors can be purchased in sets of 10 or more, as required. A trial assortment containing 36 of them costs around $55.00. A price list is available. E. P. Kretchmer.

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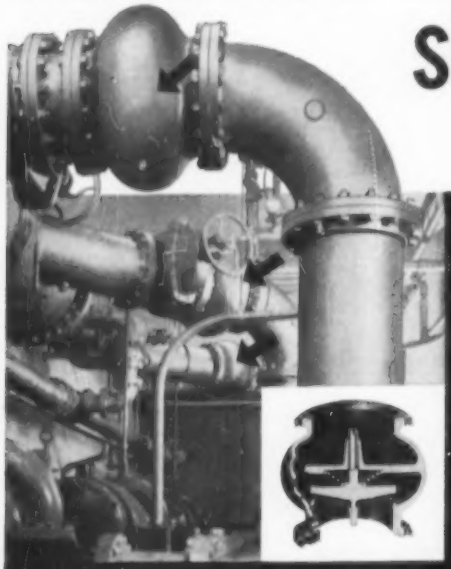

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continued from page 82

nuisances as far as repair costs are concerned, but they are very serious from the standpoint of reliable operation and costs chargeable to delayed trains.

Attempts to dig deeper into the reason for locomotive failures are often very frustrating. In all too many cases, the defect is transient and there may be many cases before the answer is uncovered.

While it is indeed true that railroad inspection and maintenance practices are not overly elaborate, the majority of failures detailed above must be charged to the fact that control devices and auxiliary equipment designed primarily for stationary service usually lack the ruggedness and simplicity needed for railroad service.

In the trend toward automatic operation there is a tendency on the part of control designers to make control systems overly complicated. There is also a tendency to overcome faults in control devices by the addition of another device rather than correcting the basic fault.

Conclusions

To date, the Union Pacific has not accumulated sufficient gas-turbine experience to assign an estimated life to turbine components. During this development period there have been so many modifications that life data on most components are very clouded. There have been some spectacular improvements in individual items such as fuel nozzles and combustion chambers, but it is still too early to tell where developments will lead.

The foregoing detailed analysis might leave the impression that gas turbines are too unreliable for locomotive power plants. A brief look at the performance record shows that the opposite is true. During the same month considered the active fleet of turbine locomotives averaged 12,026 miles, which was considerably better than any other type of freight locomotive assigned to the same district. The turbines handled 18.2 per cent of the freight hauled on the Eastern District and 11.5 per cent of the freight on the entire system. Records show that the turbine failures detailed here occurred at a rate of only 8.7 per 100,000 miles, which is not a bad record. These locomotives consistently move trains faster than other types of freight power, with the August average being 34.95 train miles per train hr. This is 6 mph faster than comparable diesel-electric units. This performance is very attractive to the Union Pacific in its constant effort to speed up freight movement. While failures cannot be ignored, they can be endured during the development of a power plant which excels in performance.

THE END

Table lists locomotive turbine defects occurring in one month

Locomotive Number	Number of Failures	Distribution			
		Control	Mechanical	Wear	Error
51	1	1			
52	2	2			
54	3	2	1		
55	1	1			
56	1		1		
58	3	1	1	1	
59	1	1			
61	1	1			
65	2	2			
67	1	1			
69	2	2			
70	2		1		1
73	1		1		
75	1	1			
—	—	—	—	—	—
14	22	15	5	1	1

Note: Table shows only defects pertaining to gas turbine and gas-turbine control.

pd

"Why Not Play Safe And Buy Your STACK As You Buy Your Car?"

"Joe, you wouldn't buy the engine of your car from one manufacturer, the wheels from another and the body from still another, would you? Neither would I. And when I design for induced draft, I specify a P-D Stack because the I.D. Fan, though it is important, isn't the whole story. The combined breeching, stack and fan, built as ONE apparatus, gives me unit responsibility, compact design, simplified engineering, and positive performance, with a lot less purchasing details.

"Another thing, I'd rather buy my Dust Collector from the same manufacturer that made my Stack and Fan. For this is all part of the same system for handling the gas after it leaves my boiler unit.

"There's nothing like putting all the responsibility on ONE manufacturer's shoulders if you can, for then you'll come out on the long end nine times out of ten. Buying such equipment piece-meal is antiquated and costly."

You can save a lot of time, trouble and money by purchasing your Stack and Dust Collector from Prat-Daniel.

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Agency—Michel-Cather, Inc.

FAIRMOUNT CHEMICAL CO., INC. 136
FELT PRODUCTS MFG. CO. ..... *
Agency—Hanson & Stevens, Inc.
FOSTER WHEELER CORP. 55
Agency—Marsteller, Rickard, Gebhardt & Reed, Inc.
FULLER CO. 61
Agency—O. S. Tyson & Co., Inc.

GENERAL COAL CO. 139
Agency—The Aitkin-Kynett Co.
GENERAL ELECTRIC CO. ..... *
Agency—G. M. Basford Co.
GLOBE CO., PRODUCTS DIV. 56
Agency—Ross Llewellyn, Inc.
GOODALL RUBBER CO. ..... *
Agency—George C. Taylor Advertising
GRAVER WATER CONDITIONING 104
Agency—Trade Method Advertising

HAGAN CHEMICALS & CONTROL, INC. 13
Agency—Ketchum, MacLeod & Grove, Inc.
HALL LABORATORIES, INC. 2
Agency—Ketchum, MacLeod, & Grove, Inc.
HILLIARD CORPORATION, THE 32
Agency—Mellor Advertising Agency, Inc.
HILLS McCANNA CO. 58
Agency—Waldie & Briggs, Inc.
HUYETTE CO., INC., THE PAUL B. ..... *

ILLINOIS WATER TREATMENT CO. 134
Agency—Cummings, Brand & McPherson
INFILCO INC. ..... *
Agency—Willard C. Gregory & Co.
INTERNATIONAL NICKEL COMPANY, INC., THE 12
Agency—Marschalk & Pratt Co. Division of McCann-Erickson, Inc.

JERGUSON GAGE & VALVE 125
Agency—Ray Elliott Co.
JOHNS-MANVILLE 101
Agency—J. Walter Thompson Company
JOHNSON-MARCH CORP. ..... *
Agency—Beaumont, Heller & Sperling, Inc.
JORDAN CORP. ..... *
Agency—Hoehnle Corp.

KAISER ENGINEERS. 119
Agency—I. C. Cole Co., Inc.
E. KEELER CO. 103
Agency—Charles E. Williams Advertising
KIRK & BLUM MFG. CO. 126
Agency—Buer, Semble & Spicer
KOPPERS CO., INC. 40
Agency—VanSant Dugdale & Co., Inc.
KOR & OXI CORPORATION ..... *
KRETCHMER, F. P. 134
KULJIAN CORP. 129
Agency—The Roland G. E. Ullman Org.

LACLEDE CHRISTY CO., DIVISION H. K. PORTER CO., INC. ..... *
Agency—Ruthrauff & Ryan, Inc.
LADISH CO. ..... *
Agency—The Cramer-Krasselt Co.
LESLIE CO. ..... *
Agency—Reid, Decker & Stackl, Inc.

MANNING, MAXWELL & MOORE, INC. ..... *
Agency—Fuller & Smith & Ross, Inc.
MARLEY CO., THE ..... *
Agency—Valentine Radford Advertising
MARYLAND SHIPBUILDING & DRYDOCK CO. 57
Agency—Speed & Company, Inc.
McCORD CORP. ..... *
MEAD-MORRISON DIVISION, McKIERNAN-TERRY CORP. ..... *
Agency—Michel-Cather, Inc.
MILTON ROY CO. 27
Agency—The Aitkin-Kynett Co.
MORTON SALT CO. ..... *
Agency—Needham, Louis & Brorby, Inc.

NAGLE PUMPS, INC. ..... *
Agency—Tri State Advertising Co., Inc.
NATIONAL AIROIL BURNER COMPANY, INC. ..... *
Agency—R. E. Lovekin Corp.
NATIONAL ALUMINATE CORPORATION 24
Agency—Armstrong Advertising Agency
NIAGARA BLOWER COMPANY ..... *
Agency—The Moss-Chase Company
NORTH AMERICAN MOGUL PRODUCTS CO., THE ..... *
Agency—Ritchie & Sattler, Inc.

OHIO INJECTOR CO. ..... Inside Front Cover
Agency—Fuller & Smith & Ross, Inc.
OLD BEN COAL CO. 38
Agency—W. S. Kirkland Advertising
OLIN MATHIESON CHEMICAL CORP. ..... *
Agency—Doyle, Kitchen & McCormick, Inc.

PERMUTIT CO., THE ..... *
Agency—Cunningham & Walsh, Inc.
PHILADELPHIA PUMP & MACHINERY CO. ..... *
Agency—The Michener Co.
PITTSBURGH PIPING & EQUIPMENT CO. 1
Agency—W. S. Hill Co.
POWELL VALVES. 53
Agency—The Ralph H. Jones Co.
PRAT-DANIEL CORP. 137
Agency—Pearsall & Schael
PRATT CO., HENRY 115
Agency—Hollander & Wegbarn
PREFERRED UTILITIES MFG. CORP. ..... *
Agency—Spooner & Kriegel
PROPORTIONEERS, INC. ..... *
Agency—Horton, Church & Goff, Inc.

RAYBESTOS-MANHATTAN, INC. ..... *
Agency—Gray & Rogers
REFRACTORY & INSULATION CORP. ..... *
Agency—Spooner & Kriegel
RELIANCE GAUGE COLUMN COMPANY 30
Agency—Carr Liggett Advertising Inc.
REPUBLIC FLOW METERS CO. ..... *
Agency—Stoetzel & Associates, Inc.
RIC-WIL, INC. 39
Agency—Ritchie & Sattler, Inc.
RILEY STOKER CORPORATION ..... *
Agency—Seth R. Martin
ROCKWELL CO., W. S. 132
Agency—Spooner & Kriegel
ROSS HEAT EXCHANGER DIVISION ..... *
Agency—Harold Warner Co.
ROTO DIV. OF ELLIOTT CO. 28
Agency—Jos. Vogel & Co.

SARCO COMPANY, INC. 51
Agency—Marsteller, Rickard, Gebhardt & Reed, Inc.
SINCLAIR REFINING CO. 63
Agency—Morey, Humm & Warwick, Inc.
SOCONY MOBIL OIL CO., INC. 10-11
Agency—Compton Advertising, Inc.
SPENCE ENGINEERING CO. 64
Agency—Michel-Cather, Inc.
STANDARD OIL CO. (INDIANA) 29
Agency—D'Arcy Advertising Co.
STEARNS MAGNETIC PRODUCTS ..... *
Agency—Bert S. Gittins Advertising, Inc.
STEPHENS-ADAMSON MFG. CO. 41
Agency—Connor Associates, Inc.
STICKLE STEAM SPECIALTIES CO. ..... *
Agency—W. H. Rabe Jr.
STONE & WEBSTER ENGINEERING CO. 33
Agency—Harold Cabot & Co., Inc.
STURTEVANT MILL CO. ..... *
Agency—F. P. Walther Jr. & Associates, Inc.
SUPERIOR COMBUSTION INDUSTRIES, INC. 122
Agency—Charles H. Davis

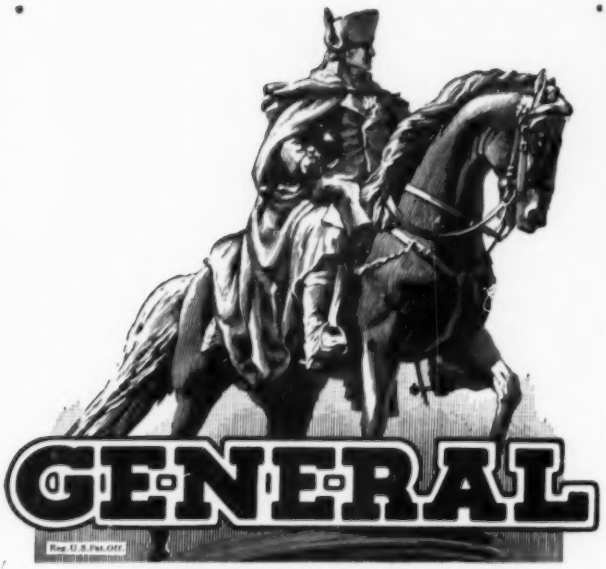
TAYLOR & CO., W. A. ..... *
Agency—Emery Advertising Corporation
THE TERRY STEAM TURBINE CO. 31
Agency—Gassaway Advertising Agency
TEXAS CO., THE ..... Back Cover
Agency—G. M. Basford Co.
TROY ENGINE & MACHINE CO. ..... *
Agency—Laux Advertising, Inc.

UNION IRON WORKS. 60
Agency—Harold Warner Co.
U. S. ELECTRICAL MOTORS. 140
Agency—The McCarty Co.
UNIVERSAL ATLAS CEMENT CO. 44
Agency—Batten, Barton, Durstine & Osborn, Inc.

VOGT MACHINE CO., HENRY 62
Agency—Farson, Huff & Northlich

WEBSTER MFG. CO. ..... *
Agency—The Morgan Advertising Co.
WESTERN CHEMICAL COMPANY 125
Agency—Carter Advertising Agency, Inc.
WESTERN PRECIPITATION CORP. ..... *
Agency—Dozier Eastman & Co.
WICKES BOILER CO. ..... *
Agency—Price, Tanner & Willox, Inc.
WILLIAMS GAUGE CO. 136
Agency—Downing Industrial Advertising, Inc.
WILSON, INC., THOMAS C. ..... *
Agency—Michel-Cather, Inc.
WORTHINGTON CORPORATION ..... *
Agency—Needham, Louis & Brorby, Inc.
YARNALL-WARING COMPANY 8-9, 66
Agency—The Michener Co.

Firms whose advertising is not in this issue but is appearing in other issues are marked with an *



Westmoreland Coal Company

HAMPTON COAL · CRITERION COAL

Stonega Coke and Coal Company

GLENBROOK · RODA · CROSSBROOK · STONEGA · DENDRON

Kentucky Sun Coal Company -
Old King Mining Company
No. 1 & No. 2

ASHLO SUNFIRE OLD KING HARDBURLY

Brown Fuel Company
HENSHAW

PREMIUM ANTHRACITE
Product of Jeddo-Highland Coal Company
Hazle Brook

Genco Anthracites & Bituminous Coals

General Coal Company

123 SOUTH BROAD STREET . . . . . PHILADELPHIA 9, PA.

Cable Address: GENCO

Branches

BUFFALO · CHARLOTTE, N. C. · CINCINNATI · CLEVELAND · IRWIN, PA. · NEW YORK · NORFOLK

For more data circle 577 on Post Card

with the

LOW NET POSITIVE SUCTION HEAD CHARACTERISTICS

of

AURORA®

CLOSE-COUPLED *TYPE B* CENTRIFUGAL
GENERAL PURPOSE PUMPS

Modern industry is confronted more and more with critical suction conditions arising from hot water and chemical handling. These extremely high efficiency, compact, flexible and low NPSH pumps are a welcome answer. You'll be glad to get the facts.

TYPE BJF FLANGE MOUNTED

IDEAL *for* THESE DUTIES

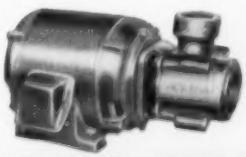
AIR CONDITIONING
REFRIGERATION
COOLANT
HOT WATER
CHEMICAL*
GENERAL PURPOSE

*MAY BE FURNISHED IN SPECIAL ALLOYS TO MEET SPECIFIC CONDITIONS

MANY VALUE FEATURES

SEAL or GLANDS — Available in either as desired.
SPEEDS — 3,500, 1,750 (60 cycle) and 2,880, 1,440 (50 cycle) speeds.
CURRENT — AC or DC — All voltages and phases.
MOTORS—1/6 to 7 1/2 H.P. drip-proof, splash-proof, totally enclosed, explosion-proof and chemical. Quiet, efficient NEMA standard.
COMPACT — QUIET — ECONOMICAL.
ALSO AVAILABLE — in Type BJP Pedestal Mounted.

TYPE BJV BASE MOUNTED



TYPE BJH HORIZONTAL

WRITE FOR BULLETIN 119J

CONSULT WITH US

Aurora engineers will appreciate specifications of your difficult jobs. Only the RIGHT pump does the job RIGHT.

PUMPS *"by Aurora"* **for EVERY NEED in INDUSTRY**

WATER SUPPLY
CONDENSATE
BOILER FEED
PROCESSING
BOOSTER
TRANSFER
ETC., ETC.,

Ask for CATALOG "M"

Your Inquiries Will Receive Prompt Attention
DISTRIBUTORS IN PRINCIPAL CITIES

AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY

40 DEARBORN ST. • AURORA • ILLINOIS

EXPORT DEPARTMENT—Aurora, Illinois—Cable Address "NYABRINT"

For more data circle 578 on Post Card

rough CONDITIONS?

TYPE J—1 TO 30 H.P.
Rerated Frames 182 to 326U

U.S. TOTALLY-ENCLOSED MOTORS

Total Protection in every direction

Large savings are being gained by many industries using *enclosed* motors in place of the usual "open" or ordinary protected motor. U.S. Totally Enclosed gives *total* protection in every direction—from corrosion, dusts, abrasives, impact, weather, spray and splash! This means motor dependability . . . long life . . . savings both on motor costs and production continuity!

Protected AGAINST CORROSION ALL EXPOSED PARTS CAST IRON . . .
Rust-resistant solid cast iron withstands abuse, wear and corrosion. *Protects* working parts!

Protected BY LUBRIFLUSH FOR LONGER BEARING LIFE
New grease forces old grease out—keeps bearings fully lubricated. *Protects* bearing efficiency!

Protected AGAINST INTERNAL HEAT WITH ASBESTOS WINDINGS
Nature's greatest heat resistor, asbestos can't carbonize! *Protects* windings against heat!

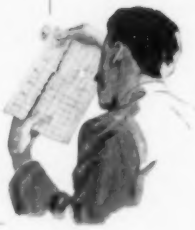
Protected FROM STRESS AND WARP BY NORMALIZING CASTINGS . . .
All cast-iron components are heat-seasoned to stabilize molecular structure. *Protected* against warp!

Write: U. S. ELECTRICAL MOTORS Inc.
Los Angeles 54, Calif. — Box 2058, Milford, Conn.
For complete information about TOTALLY-ENCLOSED MOTORS.

U.S. Electrical MOTORS

For more data circle 579 on Post Card

PREVENT BOILER CORROSION



Oxygen dissolved in boiler feed water which is a very active source of destructive boiler corrosion may be continuously detected and recorded by the Cambridge Gas Analyzer. The oxygen dissolved in the feed water is determined directly, and continuously recorded upon the Cambridge Dissolved Oxygen Recorder. The oxygen set free by dissociation in the boiler is determined by measuring the free hydrogen in the steam which is recorded upon the Cambridge Dissolved Hydrogen Recorder. Cambridge Analyzers are available in models for continuously recording either O_2 or H_2 separately or O_2 and H_2 simultaneously.

Send for Bulletin 148 B.P.

CAMBRIDGE INSTRUMENT CO., INC.
3523 Grand Central Terminal New York 17, N. Y.

CAMBRIDGE
DISSOLVED O_2 & H_2
ANALYZERS

PIONEER MANUFACTURERS OF PRECISION INSTRUMENTS
For more data circle 580 on Post Card

The easiest—and quickest—way to order bulletins and catalogs described in this magazine is to use the postage-free Reader Service Cards on pages 123–124.

All you need to do is circle the item numbers of those you want. Then fill in your name, job title, company name and address—and mail the card.

You may also use the Reader Service Cards to request information on products described, or literature mentioned in the ads—just circle the number below the ad.

THE INDEX

TO THIS VOLUME HAS BEEN REMOVED

FROM THIS POSITION AND PLACED AT

THE BEGINNING OF THE FILM FOR

THE CONVENIENCE OF READERS.

rough CONDITIONS?

TYPE J—1 TO 30 H.P.
Rerated Frames 182 to 326U

U.S. TOTALLY-ENCLOSED MOTORS

Total Protection in every direction

Large savings are being gained by many industries using *enclosed* motors in place of the usual "open" or ordinary protected motor. U.S. Totally Enclosed gives *total* protection in every direction—from corrosion, dusts, abrasives, impact, weather, spray and splash! This means motor dependability . . . long life . . . savings both on motor costs and production continuity!

Protected AGAINST CORROSION ALL EXPOSED PARTS CAST IRON . . .
Rust-resistant solid cast iron withstands abuse, wear and corrosion. *Protects* working parts!

Protected BY LUBRIFLUSH FOR LONGER BEARING LIFE
New grease forces old grease out—keeps bearings fully lubricated. *Protects* bearing efficiency!

Protected AGAINST INTERNAL HEAT WITH ASBESTOS WINDINGS
Nature's greatest heat resistor, asbestos can't carbonize! *Protects* windings against heat!

Protected FROM STRESS AND WARP BY NORMALIZING CASTINGS . . .
All cast-iron components are heat-seasoned to stabilize molecular structure. *Protected* against warp!

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U.S. Electrical MOTORS

For more data circle 579 on Post Card

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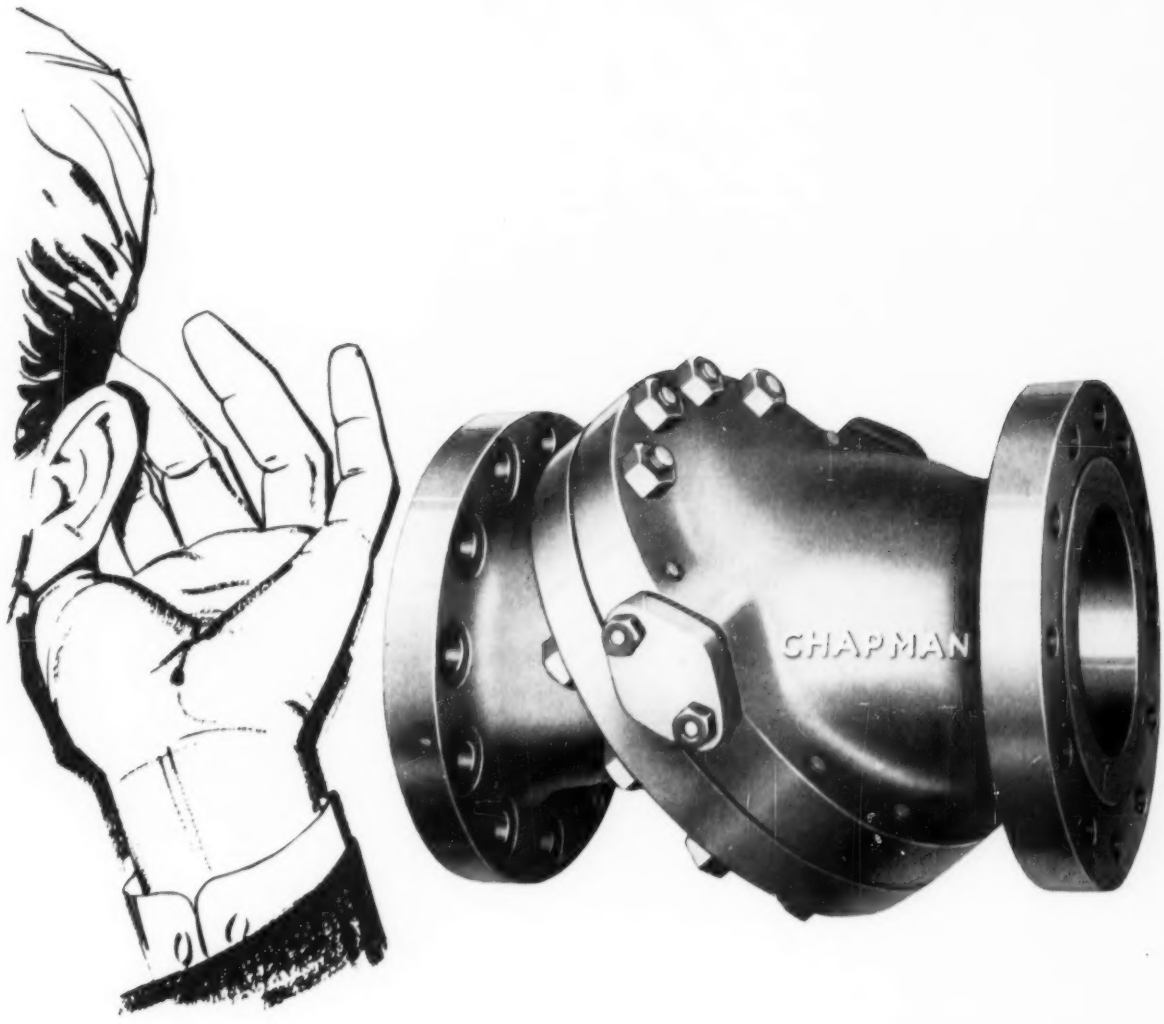


With Valves . . . there's nothing like the silent treatment!

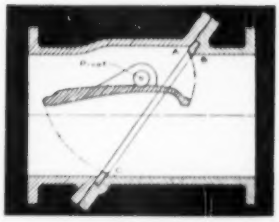
CHAPMAN Tilting Disc Check Valves

Add it all up. With Chapman Tilting Disc Check Valves you get no flutter, no vibration, no slamming or jarring or scraping of disc and seat. You get fast, sure and *quiet* operation at all times.

This is the silent treatment for valves and what it means to you is a matter of dollars and cents. You have less headaches, less trouble, less maintenance for valves and system even under severe operating conditions.

This silent treatment is an exclusive with Chapman Tilting Disc Check Valves in iron and steel . . . has been for years. These quick and quiet valves handle fluids or gases under a wide range of pressures.

You can order them for replacement or new systems. Why not, right now, check our Catalog 30-A? If you don't have a copy readily on hand, write for it today.



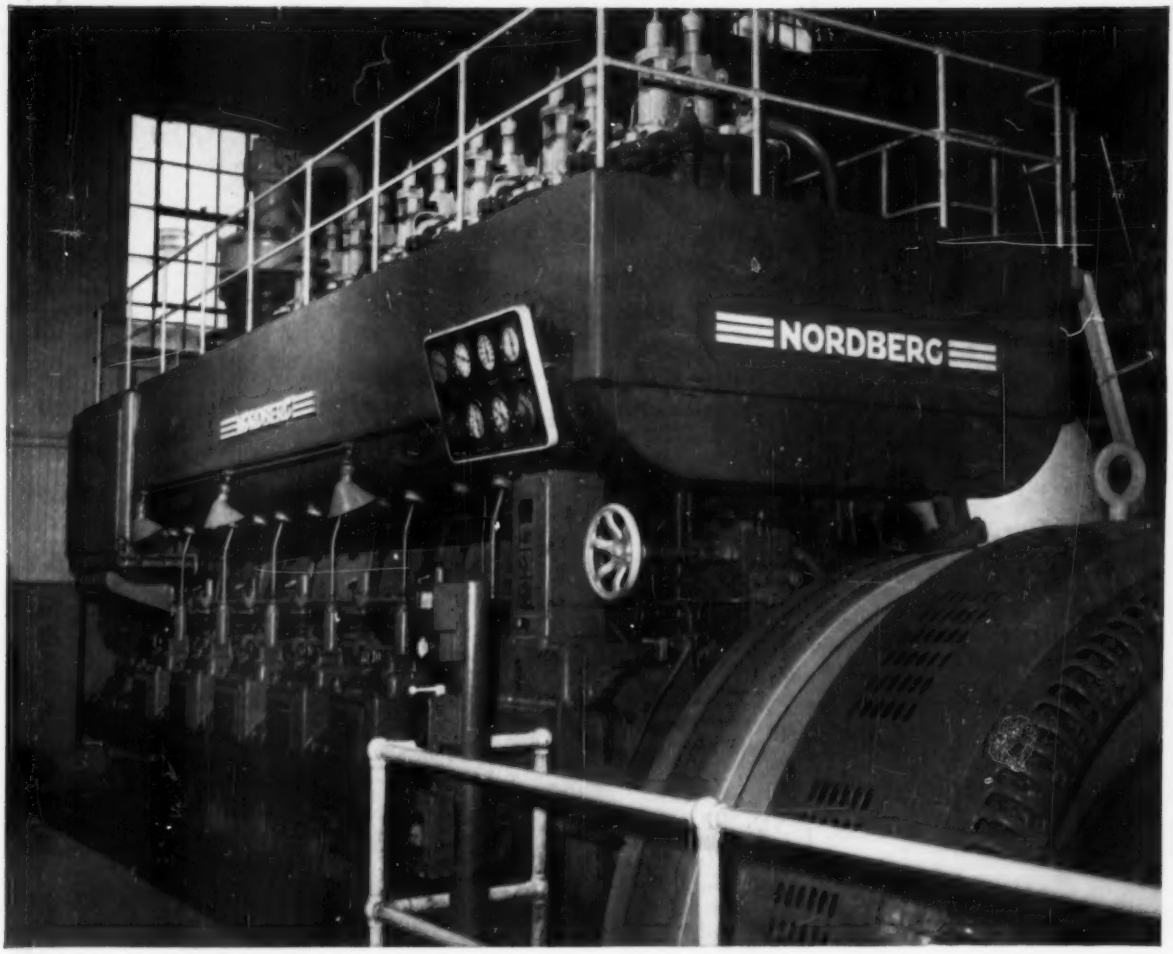
Here's the Inside Story

When the flow is on, "airfoil disc," supported on pivot, floats on whatever flow there is. When the flow stops, disc drops quickly, quietly and firmly on special bevel seat. You'll note that there is sufficient space around disc to cut down flow resistance.

THE CHAPMAN VALVE MANUFACTURING CO.

INDIAN ORCHARD, MASSACHUSETTS

For more data circle 582 on Post Card



Make sure you get the power you pay for

When fuel and maintenance bills get out of hand and power's not up to par, chances are your oil is the culprit. Let your Texaco Lubrication Engineer recommend the proper grade of *Texaco Ursa Oil*.

Texaco Ursa Oils keep diesel systems running clean for full compression and complete combustion . . . prevent harmful deposits in the combustion chamber, in crankcase and on valves. They help minimize ring, cylinder and bearing wear—all of which adds up to full power on less fuel and lower maintenance costs.

For over twenty years more stationary diesel horsepower in the United States has been lubricated with Texaco than with any other brand.

There is a complete line of *Texaco Ursa Oils* to meet the requirements of all diesel, gas and dual-fuel engines.

Just call the nearest of more than 2,000 Texaco Distributing Plants in the 48 States—or write:

The Texas Company, 135 East 42nd Street, New York 17, N. Y.

TEXACO

TEXACO URSA OILS

FOR ALL DIESEL, GAS AND DUAL-FUEL ENGINES

TUNE IN . . . METROPOLITAN OPERA RADIO BROADCASTS EVERY SATURDAY AFTERNOON

For more data circle 583 on Post Card